REPORT OF THE CHIEF OF THE BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE, 1940

United States Department of Agriculture,
Bureau of Entomology and Plant Quarantine,
Washington, D. C., August 31, 1940.

Hon. Henry A. Wallace,
Secretary of Agriculture.

Dear Mr. Secretary: I submit herewith a report of the work of the Bureau of Entomology and Plant Quarantine for the fiscal year ended June 30, 1940.

Sincerely yours,

Lee A. Strong, *Chief.*

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INTRODUCTION

The organization of the Bureau activities remains practically unchanged. The eradication and control of plant pests have been continued under a program expanded by allocations of emergency relief funds.

One of the outstanding events of the year in the work of the Bureau of Entomology and Plant Quarantine is the completion of a building in Hoboken, N. J., which is being used for inspecting importations of plants and plant products for propagation. This building was completed in time so that the force from the old in-

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spection house in Washington, D. C., was able to move in and become established and ready for business as of the last of the fiscal year 1940.

The plant quarantine inspection house in Washington, D. C., was made available in 1915 and was originally designed to receive plants imported by the Office of Plant Exploration and Introduction of the Bureau of Plant Industry. Effective August 1, 1921, quarantine No. 37 made provision for the entry of certain types of plants to be imported under special permit, and all such plants arriving at eastern ports of entry were forwarded to the Washington inspection house for examination from that date until June 27, 1940, when the force and equipment were transferred to the new inspection house at Hoboken.

The top, or fourth, floor of the new building has been specially designed and equipped to serve as a receiving station in connection with the introduction from foreign countries of parasites which may prove of value in the control of insect pests now occurring in the United States. No specially equipped facilities of this sort have been available heretofore, and it has been necessary in the past to take care of each shipment sent by the collectors abroad in the best manner possible.

PUBLICATIONS AND EDITORIAL WORK

At the beginning of the year 169 manuscripts were on hand, and during the year 481 were received, making a total of 650. Of these, 18 were withdrawn, 75 were published by the Department, and 337 were approved for publication in outside journals. There remained on hand at the end of the year 220 manuscripts, 172 of which were in the Bureau, 27 in the Office of Information, and 21 at the Government Printing Office. Of the 172 in the Bureau, 95 were being reviewed or edited for publication by the Department and the remaining 77 for publication outside.

The 75 publications of the Bureau issued by the Department included 7 circulars, 4 farmers' bulletins, 7 leaflets, 4 miscellaneous publications, 1 picture sheet, 5 service and regulatory announcements, 7 technical bulletins, 5 articles in the Journal of Agriculture Research, and 35 circulars in mimeographed form.

LIBRARY

The Bureau library records for the year show an increase of 10 percent in the circulation of books and periodicals. This spring, at the request of the librarian of the Department, the circulation of books and periodicals to the field stations and offices of the various bureaus was taken over by the Bureau libraries; a memorandum (EQ–306) and three form letters were issued covering procedure for this Bureau. Results have been most satisfactory.

Reference work for the Bureau's many divisions and offices increased appreciably; the library is frequently called on to compile lists on special subjects, e. g., the effect of color on insects, nutrient-solution insect cultures, and tree banding for insect control.

Index VI to the Literature of American Economic Entomology, 1935–39, has been continued currently and will probably be in print late in 1940 or early in 1941; 12 other special indexes have been

kept up to date, and Entomology Current Literature has been issued bimonthly.

The entomological exhibit in the patio of the administration building of the Department in April 1940 greatly stimulated popular interest in entomology, and the Bureau library has been consulted frequently ever since by high-school students and laymen seeking information. Visits to the library have not only furnished this information but have given some idea of the vast volume of literature on insects and how its contents are made available through the library.

Many additions were made to the Bureau collection of photographs of entomologists.

INSECT PEST SURVEY AND INFORMATION

The Insect Pest Survey added to the permanent files on the distribution and abundance of insects 21,000 notes on domestic insects and 12,000 on foreign insects, bringing the total now available for consultation to 348,250. To the host-plant file there were added 50 new genera and 100 new species, bringing the totals to 1,175 genera and 2,700 species.

The monthly Insect Pest Survey Bulletin was augmented by supplements on the alfalfa weevil (spread in 1939), chinch bugs (populations in hibernation, November–December 1939), the European corn borer (status in 1939, colonization of parasites in 1939, estimates of damage in 1938 and 1939, and field status of its parasites in the fall of 1938), grasshoppers (species and distribution in the 1938 outbreak), the hessian fly (survey at harvest time in 1939), the Japanese beetle (colonization of its parasites in 1938 and 1939), June beetles (population and host preferences in southern Wisconsin in 1938), and mites (distribution and food-plant records of *Paratetranychus citri* McG., *P. ilicis* McG., *P. pilosus* C. and F., *Tetranychus pacificus* McG., and *T. telarius* L.).

Ninety-one articles on entomological and quarantine subjects were released to the press and 73 radio talks were put on the air. Preparation of film-strip material covered 3 new subjects. Two new motion pictures, both of which are sound pictures, were completed—one on the white-fringed beetle and one on termites. The Bureau participated in 31 exhibits, one of which was the above-mentioned general exhibit of the Bureau's activities held in the patio of the administration building of the Department of Agriculture, which attracted large numbers of visitors and of the Department's employees and occasioned considerable press notice.

Cooperative extension work in entomology was supervised both by this Bureau and by the Office of Cooperative Extension Work.

Twelve numbers of the Bureau's Monthly News Letter, comprising 422 pages, were issued.

Publications to the number of 472,000 copies were distributed, exclusive of those sent out on regular mailing lists and of miscellaneous mimeographed material.

Orders for duplicating and photographic material, 2,324 in number, were placed for 1,277,700 copies. Of these orders, 425 were for photographic work in the Bureau's laboratory and called for

8,807 prints and negatives. The duplicating work included general Bureau mimeographing, quarantine and administrative instructions, and Bureau of Entomology and Plant Quarantine circulars. Thirty-five mailing lists were maintained in this division.

To the file of photographic prints under the custody of this division were added 569 new subjects. A total of 1,319 prints were distributed, on special request, to scientific workers, magazine editors, writers, students, teachers, and others.

A new service inaugurated was the collection of all stages of 19 different species of economically important insects, to comply with requests from schools, museums, and other educational institutions for actual insect specimens. Although this service is still practically unknown to the general public, 194 specimens were distributed to meet requests.

FRUIT INSECT INVESTIGATIONS

APPLE AND PEAR INSECTS

A study of Comstock's mealybug (*Pseudococcus comstocki* (Kuw.)) was undertaken at a new laboratory, established at Charlottesville, Va. The chief damage caused by this mealybug results from its profuse production of honeydew, which covers the twigs, leaves, and fruit. This honeydew supports the growth of a sooty mold, or fungus, which stunts the fruit and causes it to color poorly. The insect has been reported with increasing frequency since 1934 from numerous orchards from South Carolina to Ohio and Connecticut. Since thus far the use of insecticides against this insect has not been successful, special attention is being given to biological control. In 1938 arrangements were made to bring in from Japan certain parasites known to be important in the natural control of the insect in the Orient. Two of these, both of the genus *Allotropa*, were placed in heavily infested orchards in Virginia, West Virginia, and Ohio. A parasite species, *Clausenia purpurea* Ishii, already present in certain of the Eastern States, is being recolonized in Ohio, from which it has apparently been absent. Experiments are also under way with the mass liberation of the ladybird beetle *Cryptolaemus montrouzieri* Muls., stocks of which were obtained from California.

The search for a substitute for lead arsenate for control of the codling moth was continued. Approximately 250 new compounds were given laboratory testing, chiefly at Beltsville, Md. These included synthetic organic materials as well as plant extracts. Most of the compounds showed little or no toxicity; a few, including extracts of the so-called thunder-god vine, seem worth further testing. Work at Beltsville indicated that, under the laboratory technique followed there, the addition of certain sweet materials to lead arsenate, calcium arsenate, nicotine bentonite, and phenthiazine materially increased the mortality resulting from their use. This, however, has not been confirmed under orchard conditions.

A number of variations of the tank-mix nicotine bentonite formula were tested at Vincennes, Ind., by the field-laboratory method, but no improvement was found over the formula looked upon as standard for several years. The tank-mix nicotine bentonite continued to give

a high degree of control of the codling moth in commercial orchards in southern Indiana. Abnormal seasonal conditions resulted in a general prevalence of spray injury regardless of treatment, but it appeared likely that the nicotine compounds played a comparatively small part in producing this injury. In the Pacific Northwest comparatively poor results were obtained with all the nicotine sprays, in contrast to the generally favorable results in the season of 1938. No adequate explanation for this was found.

In the laboratory at Vincennes, Ind., a finely divided phenothiazine showed a higher efficiency against the codling moth than a coarse material, and was more resistant to rain weathering. Field experiments with a more finely divided phenothiazine are being conducted.

Three large-scale orchard tests of tree scraping and banding, carried on by the Yakima, Wash., laboratory, gave results consistently in line with those of earlier years, the averages being 63 percent clean fruit for the sanitation blocks and 47 percent in the check blocks. In the orchard in which the work had been carried on for five seasons one less spray application was made in the banded block than in the rest of the orchard, yet the fruit in the banded block was definitely cleaner than that in the untreated parts of the orchard.

In the orchard used for the biological-mechanical control project in West Virginia the percentage of wormy fruit was the least in 1939 for the last 5 years, in spite of the fact that the apple crop in this orchard was likewise very light. The parasitization among codling moth larvae under bands was only 4.7 percent—hardly enough to have much value for control. The percentage of larvae destroyed by predators under the bands, however, showed a slight further increase. From 1936 to 1939 this has gone from 2.3 to 13.3 percent.

Studies were made at the Yakima, Wash., laboratory of various methods of determining the periods when spring-brood codling moths emerge and lay eggs. The use of cages, periodic examinations of trees for fresh pupa skins, and bait-trap records all agreed reasonably well in their indications of the first and peak emergence, but moths continued to emerge in numbers from the trees after emergence in the cages was complete. Regular examinations of certain branches of an apple tree for eggs showed that many eggs were laid during some periods when few moths were entering the traps, and that most of the eggs were laid after the peak of moth captures in the traps had been passed.

In the Hudson River Valley two sprays of phenothiazine following a light arsenical program successfully reduced a heavy infestation of the apple maggot. Phenothiazine, used in light dosages, and xanthone did not reduce heavy infestations of the apple maggot materially, and a 15-percent phenothiazine dust was not effective.

PEACH INSECTS

The Moorestown, N. J., laboratory continued experiments in mass liberation of *Macrocentrus ancylivorus* Roh., the most effective oriental fruit moth parasite available. There was a marked increase in parasitization in orchards receiving releases early in the season, and subsequent fruit infestation was much lower than in orchards not receiving releases. At the end of the 1939 season 12 such releases had been made during 3 years, and all but one has been followed by evi-

dence of a lowering of ripe-fruit infestation the same season.

Studies and experiments are under way to develop more economical means for the mass rearing of *Macrocentrus ancylivorus*.

In the 1939 recovery work there was no exceptional change in the status of total parasitization of the oriental fruit moth. *Macrocentrus ancylivorus* continues to be the dominant species over a large part of the area surveyed. *Inareolata molestae* (Uchida) still persists in a number of localities in the Midwest, where it was last released in 1937, but the species seems to be gradually fading out there, as in other sections.

The ethylene dichloride emulsion developed by the Fort Valley, Ga., laboratory has already come into wide practical use against the peach borer. One grower reports using 6,000 gallons of the emulsion prepared on his place, from which he obtained 100-percent control with savings of 25 percent for materials and 80 percent for labor as compared with the former paradichlorobenzene treatment. Injury to peach trees in northern Louisiana was found on investigation to have been caused in part by the use of an imperfectly emulsified mixture, and in part by a sudden drop in temperature that occurred late the preceding fall.

In laboratory experiments at Fort Valley dichloroethyl ether continued effective against larvae of the plum curculio in the soil. A considerable reduction in the quantity of water used was found possible without loss of effectiveness. Conditions have not yet permitted satisfactory testing of this material under practical orchard conditions.

The mobile laboratory unit engaged in the peach mosaic work traveled over 19,000 miles during 1939, the work resulting in approximately 5,000 accessions. Many of the insects pointed to by the surveys as possibly responsible for spread of peach mosaic have already been used in transmission experiments at San Bernardino, Calif., and at Brownwood, Tex. At these 2 points a total of 1,933 tests, involving more than 100 species of insects or mites, have been carried on since the work was begun in 1938.

A start has been made in tests to determine the ability of various suspects to transmit the phony peach disease. What appears to be a very satisfactory method for handling the leaf and twig feeders has been developed, and, at the close of 1939, 114 tests were made involving over 785 individuals of some 40 species. The matter of handling the subterranean forms has presented a more difficult problem. Peach trees may be grown very easily in liquid media, thus permitting considerable manipulation of the roots, but entirely satisfactory types of cages have not yet been developed. Direct observations are difficult, since the insects react unfavorably to light. However, a number of root-transmission tests are under way.

GRAPE INSECTS

A study by the Sandusky, Ohio, laboratory of the practical use of cultivation for controlling the grape berry moth in the vineyard indicates that about 86 percent of the cocoons are found in a soil strip 18 inches wide directly under the vines. This emphasizes the importance of giving special attention to the area under the trellises, which is the most difficult to reach. Only about 18 percent of the moths are

prevented from emerging by spring cultivation as ordinarily employed. Forty-five percent of the moths were prevented from emerging by fall plowing, but the method as used in the experiment has certain serious disadvantages from a horticultural standpoint.

An all-season treatment that included four applications of phenothiazine gave a high degree of control of the grape berry moth under conditions of moderate infestation. In a severely infested vineyard the results were a little less satisfactory. The fruit showed comparatively little spray residue.

A tank-mix nicotine bentonite program that included four applications during the season gave an outstanding degree of control, even under conditions of severe infestation, but it left such a heavy deposit of visible residue as to render the fruit unmarketable, except possibly for wine or juice. In a single test, copper arsenate gave comparatively poor control of the grape berry moth.

In tests carried on in small vineyard plots, four different dust mixtures, including as active ingredients calcium arsenate, nicotine, rotenone, and pyrethrum, respectively, gave poor control of the grape berry moth.

NUT INSECTS

Field experiments for the control of the hickory shuckworm on pecan were carried on at Albany, Ga., with six spray combinations. Three of them, (1) tank-mix nicotine bentonite, (2) nicotine sulfate with rosin-residue emulsion and fish oil, and (3) a dust of sulfur and lime containing 5 percent of lubricating oil, gave definite reductions in the proportions of infested nuts. These reductions were not reflected in the total yield at harvest time, since much of the attack occurred after the shells had hardened, when shuckworm infestation does not usually reduce yield to any great extent.

Further rearings were made of parasites in overwintering larvae of the hickory shuckworm in pecan at Albany, Ga. An additional introduction was made of *Macrocentrus ancylivorus*, an important parasite of the closely related oriental fruit moth. It has not yet been determined whether this parasite will adapt itself to the shuckworm.

The Monticello, Fla., laboratory obtained a high degree of control of the pecan nut casebearer by spraying late in the summer with lead arsenate or calcium arsenate, combined with bordeaux mixture, which lessens the danger of foliage injury. This treatment would be of benefit to the crop of the following season, rather than to the current crop. The results at the same laboratory with dormant sprays of tar oil distillates for the control of the casebearer were in line with those previously reported. The Brownwood, Tex., laboratory obtained further favorable results in the control of this insect by the use of cryolite.

In northern Florida examination of pecan twigs showed that on the opening buds of an early variety the overwintering larvae of both the pecan nut casebearer and the pecan leaf casebearer were active and feeding 2 weeks earlier than on the buds of a late variety in the same orchard. Apparently the opening of the buds, rather than the direct influence of weather conditions, causes the larvae to leave their winter quarters. Pecan nut casebearer larvae were again reared

to the adult in the insectary from pecan foliage. Approximately 50 percent of the larvae included in the tests reached the adult stage.

The Eugene, Oreg., laboratory made additional collections to determine the distribution of the filbert worm (*Melissopus latiferreanus* Wals.), formerly referred to as the Catalina cherry moth. These surveys indicated the presence of the insect at least 200 miles inland from the Pacific Ocean, and at elevations ranging up to 3,600 feet. Some of the larvae of this species were found to carry over through a second winter before emerging as adults. Nearly a dozen species of parasitic wasps and flies were reared from the filbert worm or from material containing chiefly the filbert worm.

DRIED-FRUIT INSECTS

Following up the observations of a year ago that the saw-toothed grain beetle, a major storage pest of dried fruits, does not fly to any extent, the Fresno, Calif., laboratory began an experiment to determine the protection from crawling insects that might be afforded cleaned stored raisins by surrounding the stacks of boxes at the ground level with a trough barrier filled with crank-case oil.

A review of the results to date of experiments with cold storage for the control of dried-fruit insects indicates that the time-temperature combinations that may be expected to be lethal will be found to be in the neighborhood of the following figures: Saw-toothed grain beetle adults, 32° F. for less than 27 days, 36° for less than 28 days; saw-toothed grain beetle larvae, 32° for less than 15 days, 36° for less than 20 days; Indian-meal moth larvae, 32° for less than 28 days, 36° for less than 50 days; raisin moth larvae, 32° for more than 100 days, 36° for more than 115 days.

A field study of the causes of spoilage of maturing grapes in the vineyard showed that the raisin moth is a minor factor. The presence of grapes damaged by other causes, however, aids the build-up of raisin moth infestation.

SUBTROPICAL FRUIT INSECTS

The intensive laboratory work with the factors influencing the results of cyanide fumigation against the California red scale was continued at the Whittier, Calif., laboratory. With a range of temperatures from 50° to 77° F., higher mortality of the scale was secured at the lower temperatures. The influence of temperature was more pronounced in the second molt stage than in the mature stage, and in the resistant strain than in the nonresistant.

In comparative tests with the two strains of the California red scale maintained in the laboratory for a number of years, it was found that although these strains reacted similarly to pre- and post-conditioning and protective stupefaction, the reactions of the resistant strain were more pronounced. The resistant strain was apparently more sensitive to temperature changes and preliminary low dosages of hydrocyanic acid gas.

Experiments carried on at Whittier with the use of toxicants in oil for the control of the California red scale confirmed those of last year and indicated that extracts from the rotenone-containing plants are more promising toxicants than nicotine. The most effective com-

bination appeared to be a soluble oil plus cube resins. The soluble oil seemed more effective than an oil emulsion prepared with glue as an emulsifier, both when the oils were used alone and when they were combined with cube resins. The use of soluble oils as carriers for these resins also has the advantage that the solution of resins can be added to the oil just before the spray tank is filled.

When cube resins were added to light medium oils they caused a larger increase in effectiveness than when they were combined with heavy oils. In practical field experiments, in which the sprays were applied by commercial operators, mortalities of 36 percent of the adult scales on heavily infested gray wood were increased to 76 percent by the addition of cube resins. The mortality on the fruit was increased from 82 to 96 percent.

Experiments were begun at Whittier with sprays and dusts containing tartar emetic and with dusts containing potassium antimony citrate, in comparison with sulfur dust as used in the standard program for the control of the citrus thrips on lemons. Although in previous years serious injury resulted from the use of sulfur on lemon trees during the summer months, comparatively little has developed in the experimental blocks for the last 2 years.

Counts of the black scale in an orchard near Redlands, Calif., in which one section has been dusted with sulfur each year since 1936, showed 0.14 scale per unit area in the dusted part of the orchard as compared with 4.25 per unit in the undusted part. This is in line with information obtained in earlier years.

Experiments in control of the citrus rust mite were begun in September 1939 by the St. Lucie, Fla., laboratory under east coast conditions. Wettable sulfur (4,000-mesh) containing either cottonseed oil or fish oil kept mite infestations at lower levels than any other treatments. Lime sulfur alone and lime-sulfur plus alkylated sulfonated diphenyl were the two least effective sprays. The 2,000-mesh sulfur dust (without an adhesive) gave poorer control than the 325-mesh material. Similarly, the 4,000-mesh wettable sulfur added to lime-sulfur required one more application than the 325-mesh wettable sulfur in the same combination. These results were less favorable to the more finely divided sulfurs than those of a year ago.

The severe freezes that occurred in January 1940 offered an opportunity to obtain data on the effect of low temperatures on the Florida red scale. From counts of 500 adult female scales in 2 locations it was found that 32 percent survived a minimum temperature of 27.5° F. and 16 percent a minimum temperature of 23°. Owing to the number killed by the freeze, the dropping of old leaves that were infested, and the picking of the fruit, the numbers of scales were greatly reduced, although enough survived on most trees at St. Lucie to reinfest the leaves and the young fruit as it developed.

THE JAPANESE BEETLE

Investigations of the Japanese beetle were continued at Moorestown, N. J., and Spencer, N. C. By the close of 1939 the area of general distribution of the Japanese beetle was estimated at approximately 16,300 square miles, an increase of 1,183 over the previous year.

An outstanding feature of the year was a further increase in the importance of the milky disease of Japanese beetle grubs. The dis-

ease appeared in a number of additional localities in the southern part of the infested area. At one point in northeastern Maryland a population of more than 38 grubs per square foot in the fall dropped to about 6 per square foot by mid-June 1940. Two-thirds of these were affected by the disease, which was naturally present and was evidently an important cause of the marked drop in grub population. From many other heavily infested points the disease still appears to be absent, and a program to accelerate its natural spread is being developed in cooperation with various States.

During the summer of 1939 a program was undertaken, in cooperation with the New Jersey Department of Agriculture and the Division of Japanese Beetle Control of the Bureau, for colonization of the type A milky disease and the nematode *Neoaplectana glaseri* Steiner in New Jersey. In 1939, 161 locations were treated in 6 counties in New Jersey. During the winter and spring of 1939–40 the Bureau assisted in a program of the University of Maryland for distribution of the type A milky disease organism. Fresh cultures of the organism were furnished, together with full directions for preparing the spore material for field application, and part of the necessary equipment.

The work of the 1939 season indicated that a trap painted yellow is definitely superior to one painted any other color. Traps painted yellow have captured more beetles than those painted red, blue, white, or aluminum. The addition of yellow to other pigments consistently increased the effectiveness of the traps.

Laboratory testing of insecticides and repellents for use against the adult beetles was continued. In this work 1,404 cage tests were made, in which 280,000 beetles were used. Forty-five new materials were included in the tests, only one of which proved sufficiently repellent and safe on foliage to be considered as a possible substitute for lead arsenate.

During 1939 and the winter of 1939–40 a detailed investigation was made on the fumigation of balled and potted nursery stock with methyl bromide for control of the larvae as well as the eggs and adults. Twenty-two thousand eggs, 225,000 grubs, and 63,600 adult beetles were used. The adult beetles proved least resistant to the action of this fumigant, the grubs more resistant, and the eggs the most resistant. Detailed dosage requirements for complete mortality were worked out for temperatures ranging from 35° to 100° F. The most significant development of the work is that the results emphasize the importance of the conditions under which the material is held during the postfumigation period. Treatments of Japanese beetle grubs in soil balls or potted plants that appeared only partially effective at the completion of a fumigation of 2 to 4 hours gave 100 percent mortality when the stock was held at approximately the same temperature for 3 days, whereas the results at the close of the same period were poor when the stock was transferred after fumigation to locations where the temperatures were much lower.

The distribution of the 2 most valuable species of wasp parasites of the Japanese beetle was continued. Thirty-three colonies of the fall Tiphia (*Tiphia popilliavora* Roh.) were distributed late in the summer of 1939 and 151 colonies of the spring form (*T. vernalis*

Roh.) were released in the spring of 1940, in several States and the District of Columbia. In addition, 2,500 females of *T. vernalis* were furnished the University of Maryland for use in a program of mass rearing for subsequent liberation.

THE PEAR PSYLLA IN THE NORTHWEST

A program for the suppression of the pear psylla in the Pacific Northwest was undertaken in cooperation with State agencies in Washington and Idaho, with funds allotted from the appropriations for the control of incipient and emergency outbreaks of insect pests and plant diseases. During July 1939 the pear psylla, an extremely destructive insect which has been present in the northeastern part of the United States for more than 100 years, was found for the first time in the Pacific Northwest in a very limited area in Washington and Idaho, near Spokane, Wash. Cooperative surveys participated in by various State agencies failed to reveal its presence in the main pear-producing areas of Washington, Oregon, and Idaho.

The area in which the insect was first found in the Northwest appeared to be limited in extent to approximately 225 square miles and to involve not more than 12,000 pear trees, mostly in dooryards or small home orchards. Because of the comparatively small number of trees concerned, and the presence of mountain or desert barriers between the infested district and the important pear-producing areas, the chances appeared favorable for preventing the spread of the insect and for its ultimate eradication from the Northwest.

An organization was set up at Spokane in February 1940 to deal with the problem. Intensive scouting early in the season of 1940 revealed that light infestations existed on additional properties in the Spokane Valley, which increased the area involved to 4,500 square miles and increased the number of trees involved to about 28,000. The infested area is still reasonably well isolated, and ultimate eradication of the insect still appears feasible.

An intensive program of spraying is under way, and the infestation has been markedly reduced. The cooperating States have promulgated quarantines to prevent the accidental movement of the insect in a number of farm products grown or packed near infested pear trees. A great many individual trees have beeen removed by the owners or under waivers signed by the owners.

Several laboratories of the Division have made contributions to the program. The personnel of the Yakima, Wash., laboratory surveyed the upper Yakima Valley during the summer of 1939, and this survey is being repeated during the summer of 1940. The Moorestown, N. J., laboratory conducted numerous experiments with fumigation with methyl bromide against the pear psylla. The insects needed for this work were furnished partly by the New York Agricultural Experiment Station at Geneva and partly by the Bureau laboratory at Poughkeepsie, N. Y. On the basis of information obtained, farm products which may be infested are being allowed to move out of the infested areas in the Spokane Valley after fumigation.

FRUITFLY INVESTIGATIONS

The results of fumigation studies in Hawaii with methyl bromide have permitted authorization for shipment of products to the mainland after fumigation. A spray giving good control of the melonfly in Hawaii was developed. A potent lure for the melonfly was found. Synergistic action in connection with repellents for the Mexican fruitfly was demonstrated. Studies on the fruitfly attacking citrus in Puerto Rico have resulted in a lessening of the restrictions which apply to the citrus industry in Puerto Rico from the standpoint of domestic quarantines.

MEXICAN FRUITFLY CONTROL

INFESTATIONS

Early in January it appeared that another serious fruitfly infestation was in prospect for the lower Rio Grande Valley. Traps indicated the presence of a considerable fruitfly population which it was believed would cause a general heavy infestation before the season was over. The low temperatures late in January, however, disrupted normal fruitfly activity, and only 27 percent as many groves were found infested as were known to have been infested during the preceding season. The fly population was mounting when harvesting was completed on April 30, but as no fruit was available for oviposition, the number of plantings infested was reduced accordingly.

Table 1 shows, for the years 1935–40, the number of infestations in relation to the number of flies trapped and the date the harvesting season closed.

TABLE 1.—*Infestations of the Mexican fruitfly in Texas, 1935–1940*

Fiscal year	Flies trapped	Larval infestations	Harvesting closed	Fiscal year	Flies trapped	Larval infestations	Harvesting closed
	Number	*Number*			*Number*	*Number*	
1935	367	30	Apr. 2	1938	712	218	Apr. 30
1936	251	5	Mar. 31	1939	13,687	2,141	[1] May 15 [2] June 15
1937	4,714	1,062	Do.				
				1940	6,157	[3] 582	Apr. 30

[1] For grapefruit.
[2] For oranges.
[3] Including 4 infestations in fruit of 1939.

STERILIZATION

There are two approved fruit-sterilization processes. The low-temperature method consists of lowering the inside fruit temperature to 30°–31° F. and holding it there for 15 days. This method is used for a relatively small amount of fruit, as considerable more time is required, and the process is somewhat more expensive than the high-temperature treatment.

The vapor-heat method consists of raising the inside fruit temperature to 110° F. and holding this for 6 hours. The approach and sterilization periods require a minimum of 14 hours, and the entire process must be carried out in specially adapted fruit rooms.

Throughout the time the fruit is receiving the treatment, air with 100-percent humidity is forced into and drawn from the rooms. The heat and humidity are obtained by injecting steam into the air-conditioning unit.

Owing to the reduction in the number of citrus plantings found infested during the year, only about 20 percent as much fruit was sterilized as was treated in the preceding season.

Table 2 lists the amount of fruit sterilized by the two approved methods in the fiscal years 1939 and 1940.

TABLE 2.—*Citrus fruit sterilized in Texas, fiscal years 1939 and 1940*

Fiscal year	By high-temperature method		By low-temperature method	
	Grapefruit	Oranges	Grapefruit	Oranges
	Tons	*Tons*	*Tons*	*Tons*
1939	44,150.0	2.25	2.08	0
1940	8,926.9	.75	298.6	168.80

FRUIT PRODUCTION AND SHIPMENTS

The citrus fruits harvested and shipped were 1,093 equivalent carlots less than the amount moved last season. The total production reached 46,455.4 equivalent carlots, and of this amount 19,217.3 equivalent carlots were processed.

Table 3 shows the fruit production and methods of distribution from the Rio Grande Valley of Texas for the fiscal years 1933 to 1940.

TABLE 3.—*Citrus fruit from the Rio Grande Valley of Texas, shipped and canned, and total production, in equivalent carlots, fiscal years 1933–40*

Fiscal year	By rail		By truck		By boat		By express and passenger car mixed	Canned grapefruit	Commercial production
	Grapefruit	Oranges	Grapefruit	Oranges	Grapefruit	Oranges			
	Carlots	*Carlots*	*Carlots*	*Carlots*	*Carlots*	*Carlots*	*Carlots*	*Carlots*	*Carlots*
1933	2,897	230	880	586	----------	----------	101	127	4,821
1934	1,748	114	1,236	877	----------	----------	99	240	4,314
1935	4,617	225	1,731	1,095	----------	----------	239	1,131	9,038
1936	4,262	600	1,454	1,182	----------	----------	267	1,682	9,447
1937	15,616	2,729	2,578	2,351	176	17	532	[1] 6,702	30,701
1938	13,736.3	1,322.7	2,817.4	1,991.5	183.1	4.7	593.1	14,278.6	34,927.4
1939	16,571.6	1,938.5	5,868.3	5,399.3	521.5	12.2	626	[2] 16,611	47,548.4
1940	12,758.5	1,323.9	7,239.0	4,734.2	579.5	3.0	600	[3] 19,217.3	46,455.4

[1] Includes 2 cars of oranges processed.
[2] Includes 35 cars of oranges processed and 4,304 cars of grapefruit for diversion under Federal Surplus Commodities Corporation program.
[3] Includes 84.6 cars of oranges processed.

JAPANESE BEETLE QUARANTINE AND CONTROL

TRAP SCOUTING IN NONREGULATED TERRITORY

Trap scouting for the Japanese beetle in 1939 was begun on April 11 with the setting of traps at Presidio, Tex., and continued until September 15, when all trapping for the season was completed. During the season 79,537 traps were distributed by the Bureau in 491 cities and

towns in 38 States. With the exception of Arkansas, Montana, Nevada, Oklahoma, and South Dakota, some degree of trapping was undertaken in all States outside the main infested territory.

Most of the trapping was centered in the States of New York, North Carolina, South Carolina, Ohio, Pennsylvania, Virginia, and West Virginia, and in the cities of Atlanta, Ga., Chicago, Ill., Indianapolis, Ind., Louisville, Ky., Detroit, Mich., and St. Louis, Mo. The States mentioned were already partially infested or contiguous to the main infested zone, and isolated infestations had been found in the heavily trapped cities.

Trapping showed a carry-over of infestation in 78 cities and towns in nonregulated territory and 48 first-record infestations, 5 of which were in Indiana, 7 in Maryland, 3 in Michigan, 6 in New York, 8 in Ohio, 5 in Pennsylvania, 3 in Virginia, and 11 in West Virginia. Of the first-record finds, 29 were incipient infestations of a few beetles each, whereas 19 were of such scope, or were in such proximity to the main regulated area, that they were later added to that area.

Trapping which yielded negative results was performed in Alabama, Arizona, California, Colorado, Florida, Idaho, Kansas, Louisiana, Minnesota, Mississippi, Nebraska, New Mexico, North Dakota, Oregon, Texas, Utah, Vermont, Washington, Wisconsin, and Wyoming, 1,504 traps having been set in 142 towns and cities in these States.

In Georgia 3,600 traps were set in Atlanta and suburbs, with resulting captures of 40 beetles in Atlanta and 142 in East Point. No beetles were found at Jonesboro and Savannah, where 3 and 1, respectively, were found in 1938. Trapping with negative results was performed in 15 other localities in the State.

In Illinois 549 beetles were trapped in Chicago, 2 in Cicero, 24 in East St. Louis, and 16 in Evanston. By comparison with 1938, Chicago, East St. Louis, and Evanston showed respective beetle increases of 219, 23, and 15, whereas there was a decrease of 3 beetles in Cicero. Trapping in 1 other community gave negative results.

In Indiana trap scouting was conducted in 21 localities, with positive results in 10 and negative in 11. The first-record infestations were at Bluffton, 2 beetles; Hammond, 3; Muncie and Richmond, 1 each; and Warsaw, 2. No beetles were trapped in East Chicago and South Bend where a few beetles were found in 1938. Other beetle captures this year, as compared with 1938, increased from 2 to 5 in Elkhart, 20 to 105 in Fort Wayne, 10 to 76 in Indianapolis, 8 to 98 in Logansport, and 1 to 18 in Whiting.

In Iowa no beetles were trapped in 1939 at Fort Madison, although a first-record infestation was found there in 1938. Trapping in two other communities in the State gave negative results.

In Kentucky 600 traps were set in Lexington, with negative results, although trap captures of a solitary beetle each were made there in 1936, 1937, and 1938. At Louisville 13 beetles were caught in 1,600 traps, a decrease of 49 as compared with the 1938 figure of 62 beetles found in 1,566 traps.

In Maine 899 traps were operated in 7 localities in the nonregulated section; 400 of these were used at Bangor, where 5 beetles were caught. Results were negative in the 6 other Maine localities trapped.

Maryland officials in charge of the cooperative Japanese-beetle-retardation campaign in that State arranged for the distribution of

approximately 100,000 traps throughout some of the more heavily infested portions of the State during the summer of 1939, with a resulting capture of over 104 tons of beetles. In the nonregulated territory of Maryland first-record trap captures were made in 7 localities. Trap captures in the 15 established infestations in this State ranged from 9 to 1,189 beetles.

In Michigan, from July 6 to August 31, 5,250 traps were used in Detroit, and during this period 115 beetles were caught—an increase of 33 over the number captured with 5,313 traps in 1938. Five beetles were trapped at Dearborn, where a solitary beetle was captured last year. Trapping resulted negatively at Highland Park and Pontiac, where first-record infestations were found the previous year. Three first-record trap captures were made. These were incipient infestations of 6 beetles at Birmingham and 5 beetles each at Grosse Pointe farms and Melvindale. Negative trapping was carried on in 5 additional localities.

In Missouri 13,666 traps were in operation; 12,230 being in St. Louis, where 26 beetles were caught, and 1,436 distributed in 15 other localities, where trapping gave negative results.

In New Hampshire, although 323 traps were set at 6 points, not a single beetle was caught. There has been no beetle persistence in the nonregulated section of this State since 1933.

In New York first-record infestations of a few beetles each were recorded at Auburn, Batavia, Dundee, Mayville, and Penn Yan. An infestation of 20 beetles was discovered this year in the village of Painted Post. Previously discovered infestations recurred at Canandaigua, Dansville, Geneva, Newark, and Seneca Falls. Beetle collections in Dansville showed a substantial increase. A total of 2,550 traps were set in 43 cities and towns, with positive results in 11 localities.

In North Carolina, where 9,525 traps were used, beetles in varying numbers were caught in 20 previously infested communities, substantial increases being noted in several points. Asheville, where 1,073 beetles were trapped in one section of the city, was not included in the large acreage treated in the State during 1939 owing to local conditions. Trapping will be repeated in that city and further suppressive measures will be worked out with the North Carolina State entomologist.

In Ohio trapping in the nonregulated section extended to 111 towns and cities, with positive results in 17 localities. These included first-record trap captures at 8 points, 5 of which were incipient infestations of a few beetles each in isolated localities that are of minor importance from the standpoint of spread. Sizable infestations were discovered at Martins Ferry, North Salem, and Seville. Infestations continued in 10 towns and cities. Scouts located 230 beetles in Mentor as compared with 132 caught there by scouts in 1938. Trapping giving negative results was performed at 94 additional points.

In Pennsylvania trapping was carried on in 8 cities and towns, with resulting captures in 7 localities. These included first-record finds of 13 beetles each in Corry and Franklin, 1 in Greenville, 7 in Meadville, and 6 in Titusville. At Erie 437 beetles were caught in 2,400 traps, as compared with 343 beetles captured in 2,355 traps in 1938. Beetle captures at Oil City increased from 26 in 1938 to 238 in 1939,

with the use of 400 traps each year. Traps set in Union City failed to catch any beetles.

In South Carolina 5 beetles were caught in 800 traps at Greenville. Collections in that locality indicated that beetles have persisted in negligible numbers since 1936. Although traps have been set in Florence from 1935 to 1939, inclusive, not a single beetle has been caught there. Trapping in Charleston also gave negative results.

In Tennesseee trapping, which resulted negatively, was performed in four localities. There has been no beetle persistence in the State since four beetles were caught at Bristol in 1936.

In Virginia 3 first-record trap captures were incipient infestations of 1 beetle each at Rappahannock Academy and Unionville and 3 beetles at Berryville. A total of 2,122 traps were distributed in 32 cities and towns, with positive results at 8 points and negative results in 24 communities. At Winchester 9 beetles were caught in 397 traps as compared with 25 captured with 383 traps in 1938.

In West Virginia trapping was carried on in 40 cities and towns, with resulting captures in 15 localities. These included first-record finds at Bakerton, Buckhannon, Elkins, Follansbee, Halltown, Kearneysville, Millvale, Shenandoah Junction, Shepherdstown, Wellsburg, and Weston. Recurring infestations at Charles Town and Charleston increased slightly in number of beetles trapped.

In Florida early season trapping activities during 1940 began with the placement of traps in Monticello, on April 1. Trapping was completed before July 1 in 19 localities. At the end of the year traps were in operation in 166 cities and towns in 31 States.

Trap captures recorded during May and June 1940 included 4 beetles at Jacksonville, 2 at Miami, and 1 at Tampa, Fla.; 9 at Atlanta, 4 at Chamblee, 74 at East Point, and 2 at Gainesville, Ga.; 1 at Louisville, Ky.; 18 at St. Louis, Mo.; 15 at Burlington, 15 at Charlotte, 28 at Durham, 7 at Elizabeth City, 28 at Greensboro, 11 at High Point, 4 at Lexington, 11 at Raleigh, 9 at Rocky Mount, 19 at Salisbury, 61 at Spencer, 407 at East Spencer, 8 at Sanford, 2 at Weldon, 32 at Wilmington, and 125 at Winston-Salem, N. C.; 2 at Belpre and 36 at Gallipolis, Ohio; and 12 at Charleston, 1 at Florence, and 6 at Greenville, S. C. The finds in the following cities and towns were first records: Jacksonville, Miami, and Tampa, Fla.; Chamblee and Gainesville, Ga.; and Weldon, N. C.

SUPPRESSIVE MEASURES

Lead arsenate was applied for control of the Japanese beetle to a total of 888.79 acres of soil in Georgia, Illinois, Indiana, Michigan, Missouri, New York, North Carolina, Ohio, and Virginia.

Following the discovery of a first-record infestation in the Atlanta suburban area of East Point, Ga., 10.4 acres were given applications. The treatment was begun on August 21 and completed by the end of September.

In Illinois 117.2 acres were treated in Chicago, East St. Louis, and Evanston during the period July 5 to October 19.

In Indiana field treatments were resumed in the fall of 1939, with 12.1 acres treated at Fort Wayne, 53.4 at Indianapolis, 31.6 at Logansport, and 13.3 at Whiting. In Indianapolis 22.1 additional acres were treated between April 1 and 11, 1940.

In Michigan, from September 18 to November 15, 63 acres were treated, approximately 50 acres in Detroit and the remainder in Dearborn, Birmingham, Grosse Pointe, and Melvindale.

In St. Louis, Mo., applications were made to 27 acres to cover the premises on which 26 beetles were trapped in the summer of 1939. Not one beetle was caught in treated areas where previously hundreds had been taken.

At Dansville, N. Y., the local nurserymen's association, acting on the advice of State officials, initiated their own soil-treating program, contributing one-half and underwriting the other half of the $4,000 required to treat an infestation that has not yet spread to any of the extensive nursery-growing sections in that vicinity. During the first 2 weeks of November 19.3 acres in Dansville were treated in the area where 116 beetles were discovered during the 1939 trapping season.

In North Carolina 302.5 acres in 17 cities and towns received applications. Every known infestation in the State, excepting 1 at Asheville, was treated at a dosage of 1,000 pounds per acre. Treatment was begun September 25 and completed December 16.

In Ohio 4 acres were treated at Belpre between June 29 and July 6, 1939. At Ashtabula, Belpre, Conneaut, Gallipolis, and Marietta 166.35 acres received applications during the spring of 1940. At Zanesville 12.6 acres were sprayed between May 10 and 21.

At Berryville, Va., where three beetles were trapped in the summer of 1939, 4.34 acres received applications between December 11 and 13. From March 11 to April 3, 1940, 29.5 acres in Winchester were treated.

Throughout the year the treating work has been largely sponsored by either the State or the municipalities affected. The Bureau's contribution included furnishing spray equipment, drivers for the spray trucks, and supervisors to cooperate with the men in charge of the work for the sponsoring agency. Labor and materials were furnished by the cooperating agencies, which also made all local arrangements.

FEDERAL AND STATE REGULATORY MEASURES

At a public conference held in Washington, D. C., on February 27, 1940, to consider the present status of the Japanese beetle quarantine, there was a large attendance of nursery association representatives, State plant-pest officials, and others interested. This was the first public meeting to consider this quarantine since the hearing held on November 16, 1935. A majority of those present favored retention of the quarantine.

This year there was no necessity to consider the advisability of placing any additional States under quarantine. With the exception of Asheville, N. C., all important infestations discovered in unquarantined States were treated with a dosage of lead arsenate sufficient to eliminate all hazard of beetle spread from these communities.

By an amendment to the Japanese beetle quarantine regulations, effective July 1, 1939, four townships in Cuyahoga County, Ohio, were added to the regulated area, bringing the entire county within the area. With the extension of the continuous regulated area to include Cleveland, all restricted commodities moving from this point

to nonregulated territory require certification. The amendment also removed the regulated portion of Steuben County, N. Y., other than the town of Hornellsville, from its previous status as an isolated area to which the movement of certain quarantined articles could be made only under certification.

Termination of the restrictions on the interstate movement of fruits and vegetables was advanced from October 16 to September 20 for the year 1939, in accordance with administrative instructions dated September 19, 1939.

A further amendment to the regulations was issued, effective April 5, 1940, extending the regulated areas in Maryland, New York, Ohio, Pennsylvania, and West Virginia. Corry and Erie, Pa., and Charleston, W. Va., were placed under regulation as isolated points. The amendment further provided that the special area from which the movement of fruits and vegetables by motortruck or refrigerator car is regulated be extended to New York City and surrounding area, including one town in Connecticut, as well as additional areas in Maryland, New Jersey, and Pennsylvania.

Effective May 27, 1940, regulations under the Japanese-beetle quarantine on the movement of fruits and vegetables were modified to limit the restrictions to such articles moving from the area of heavy adult flight via refrigerator car or motortruck. Under this amendment restrictions were lifted on the movement of small, noncommercial shipments of fruits and vegetables by passenger vehicle, parcel post, freight, and express.

Administrative instructions were issued on June 20, 1940, to remove from the heavily infested area the tidewater Virginia area surrounding Norfolk and Portsmouth.

Revised intrastate quarantines were issued by Missouri, New York, Ohio, and West Virginia. Missouri and West Virginia extended their regulated areas.

HIGHWAY INSPECTION SERVICE

To cope with the increased trafficking in quarantined products during July, 7 stations were added to those that had been in operation at the end of the previous fiscal year. On July 31 there were 26 regular and 8 floater stations in operation in Ohio, Pennsylvania, Virginia, and West Virginia. Thirteen regular stations and 2 floater stations were in Virginia; 2 regular and 4 floater in West Virginia; 10 regular and 2 floater in Ohio; and 1 regular station in Pennsylvania. During the summer the maximum number of road inspectors employed for operation of the posts was 79.

Closing of the regular stations began on September 9, and by the end of October only two regular stations were in operation, both in the vicinity of Fredericksburg, Va. One of these was discontinued on November 12 and the other on November 14.

Road-patrol activities in the spring of 1940 began during the third week of April with the opening of five road stations to inspect southbound traffic from the Virginia regulated zone. In West Virginia one station was opened on April 17; and in Ohio seven stations were set up between April 26 and 28, most of them with two inspectors each, operating 16 hours a day.

Posting of the most important highways was concluded early in May with the additions of one station in Virginia and two in Ohio. When the seasonal restrictions on fruits and vegetables became operative on June 15, eight additional stations were opened in Virginia. Inspection personnel was increased during June and full quotas of men were assigned to the posts by June 17.

During June 1940, 24 road stations were in operation. Of this number 14 were in Virginia, 1 in West Virginia, and 9 in Ohio. Toward the end of June 3 special floater stations were opened in Virginia and 1 each in Maryland and West Virginia.

Empty trucks returning to southern points after driving through sections in which beetles were swarming were found to contain 7,778 live beetles.

Eighty-four lots of infested plant material were intercepted at the posts, from which were removed 9 adult beetles and 274 grubs.

Counts of all motor vehicles stopped at the road stations for inspection during the year totaled 4,117,608. Uncertified quarantined products were found in 22,665 vehicles.

CERTIFICATION AND TREATMENT OF NURSERY STOCK

As a result of scouting during the summer of 1939 within the regulated area, 3,313 beetles were found on the premises of 204 nurseries and greenhouses, and 749 beetles within a 500-foot radius of 79 other establishments. In the New England States 70 establishments were found infested in Connecticut, 7 in Massachusetts, 1 in New Hampshire, and 2 in Rhode Island. Nursery infestations in the other States in the regulated area were as follows: Delaware, 16 establishments; Maryland, 52; New Jersey, 2; New York, 24; Ohio, 1; Pennsylvania, 21; Virginia, 7; and West Virginia, 1.

Twenty nurseries that were assigned to class III, as the result of one or a few beetles found on the premises in previous years, were rescouted during the summer of 1939 to determine their eligibility for restoration to an uninfested status. Seven establishments were found free of infestation and accordingly reverted to class I or preferred status. Two units were granted preferred status in part. Nursery and greenhouse scouting was completed by the middle of September.

Among the latest reports of adults observed was the collection of 150 beetles and the observation of additional beetles at Bedford, Westchester County, N. Y., on October 10. The beetles were as active as at any time during the summer. October 10 was also the latest date on which adults were observed in Connecticut, several specimens having been collected on that day in New Haven. The Philadelphia, Pa., office reported that the last Japanese beetle was found in that area on November 28.

Large quantities of nursery and greenhouse stock were certified for movement from infested establishments within the regulated area. A large number of shipments originating on noninfested establishments within the regulated area were also certified. In April 87 carloads of nursery stock were shipped from New Jersey.

A few additional inspectors were employed in March to take care of increased demands for the inspection and certification of greenhouse and nursery stock. An extra inspector was hired for assignment during the remainder of the spring shipping season at one of

the larger Delaware nurseries. Another temporary inspector was stationed during March at a large greenhouse establishment in the Philadelphia area to handle the many shipments of certified Easter plants.

Further experiments with methyl bromide, first authorized as a fumigant on February 15, 1939, and limited to stock with soil balls not in excess of 8 inches in diameter, showed that all living larvae of the Japanese beetle are killed in 12-inch pots or soil balls when the treatment, dosage, and temperature are properly regulated. Administrative instructions were accordingly issued on November 4, enlarging the scope of the methyl bromide fumigation procedure to include balled nursery stock not larger than 12 inches in diameter. During the remainder of the year this method of fumigation furnished an outlet for large quantities of nursery and greenhouse stock that theretofore could not be satisfactorily treated to eliminate possible grub infestation. There is widespread interest among growers in this simplified method of producing beetle-free stock.

A new edition of the Shipper's Guide, enlarged to contain the cities and towns added to the regulated area with the revision of the regulations effective April 5, 1940, was distributed in June.

In cooperation with the Division of Insecticide Investigations 764 soil samples were collected and analyzed from nursery plots, heeling-in areas, and frames previously treated with lead arsenate. As a result of these analyses, 336,309 square feet were retreated to bring the insecticidal content of the soil up to the required dosage. In addition, 461,372 square feet of nursery area received their initial applications of lead arsenate.

Nurseries and greenhouses fulfilling the requirements for classification under the quarantine regulations decreased during the year from 2,514 to 2,075. This decrease was due to stricter requirements that were set up for the maintenance of classification. Under former regulations it was possible for many establishments to retain their classification despite the fact that they rarely asked for certification and did little or nothing to produce grub-free stock. They were in practically the same status as an unclassified grower so far as their ability to ship was concerned. Establishments classified at the end of the year, numbering 1,642 class I or uninfested units and 432 infested or intermediate units, include only those actively engaged in the production and shipment of certified material. Most of those formerly classified are obtaining their certification on daily call by an inspector. As methyl bromide fumigation of stock comes into more general use, it is anticipated that the system of classification will further decline, with shippers depending more and more upon the fumigation of stock in the presence of an inspector to take care of their certification requirements.

CERTIFICATION OF FRUITS, VEGETABLES, AND CUT FLOWERS

Inspection centers were in operation at 40 points throughout the regulated area during the period of adult beetle flight in 1939. Eight were in Delaware, 6 each in Maryland and New York, 5 in Virginia, 4 in New Jersey, 3 in Pennsylvania, 2 each in Massachusetts and Ohio, and 1 each in Connecticut, District of Columbia, Maine, and West Virginia.

Activities in connection with the summer quarantine on fruits and vegetables were heavy on the Eastern Shore of Maryland and Virginia and in Delaware during the month of July, although the work was considerably under the same period of last year. This was due to a decrease in the methyl bromide fumigation of loaded refrigerator cars caused by a reduction in the potato crop as a result of dry weather.

Over 300 truckloads of fruits and vegetables were certified in August for movement from New Jersey to Virginia, North Carolina, South Carolina, Georgia, and Florida.

Restrictions on the movement of cut flowers remained in effect until October 15, although the seasonal quarantine on fruits and vegetables was lifted on September 20. The fumigation of farm products in refrigerator cars with methyl bromide ended for the season on September 9.

During the period of the quarantine on fruits, vegetables, and cut flowers, inspectors removed 2,642 adult beetles from 3,245,495 packages of commodities certified for transportation.

ARTICLES CERTIFIED, VIOLATIONS INVESTIGATED, AND PROSECUTIONS TERMINATED

A total of 501,205 certificates of all kinds were required to cover quarantined products moving to nonregulated territory.

Table 4 shows the quarantined articles, intended for shipment from the regulated area and for use in certified greenhouses, or surface soil in nursery plots, in heeling-in areas, or in plunging areas, which were fumigated or sterilized during the 12-month period.

TABLE 4.—*Materials fumigated or sterilized under Japanese beetle quarantine regulations, fiscal year 1940*

Treatment	Plants	Potting soil	Surface soil	Surface soil with plants	Berries
	Number	*Cubic yards*	*Square feet*	*Square feet*	*Crates*
Lead arsenate	194,912		559,636	3,453,800	
Carbon disulfide	2,107	1,713	17,710		
Paradichlorobenzene	58,726				
Naphthalene		47	49,064		
Steam		459	20,664		

Treatment	Plants	Potting soil	Sweet-potatoes	Onions	Tomatoes	Mixed ship-ments	Empty cars
	Number	*Cubic yards*	*Cars*	*Cars*	*Cars*	*Cars*	*Number*
Methyl bromide	771,782	23	162	8	78	2	
Hydrocyanic acid				10			5,686

Treatment	Beans	Cabbage	Potatoes	Carrots	Eggplant	Peppers
	Bushels	*Cars*	*Cars*	*Bushels*	*Bushels*	*Bushels*
Methyl bromide	490	54	1,009			
Hydrocyanic acid	12		3	586	61	452

Nursery and ornamental stock, sand, soil, earth, peat, compost, and manure were certified for shipment from the regulated areas during the year in the following quantities:

Plants	number	36,595,646
Sand, earth, and clay	carloads	288
Peat	do	12
Compost and manure	do	283
Stolons	square feet	3,237

Fruits, vegetables, moss, and cut flowers certified during the seasonal quarantine on these articles were as follows:

Fruits and vegetables	packages	3,209,527
Moss	pounds	26,301
Cut flowers	packages	35,968

In addition 242,741 shipments were made by class I establishments to points in nonregulated territory and between establishments in the regulated area.

Investigations were made of 1,869 apparent violations of the Japanese beetle quarantine regulations. These included interceptions by transit inspectors of the Bureau stationed at postal and common-carrier terminals and by highway inspectors examining road vehicles. A conviction was secured for one of these violations.

COOPERATIVE ENTERPRISES

State funds for cooperative control or quarantine activities were provided by Connecticut, Delaware, Georgia, Illinois, Indiana, Maine, Maryland, Massachusetts, Michigan, Missouri, New Hampshire, New Jersey, New York, North Carolina, Ohio, Pennsylvania, Rhode Island, Vermont, Virginia, and West Virginia.

Total contributions from State, city, and Federal welfare agencies for trapping and soil treatments during the year amounted to $296,189.

Experimental work with the nematode *Neoaplectana glaseri* in controlling established infestations of the Japanese beetle was continued at the laboratory at White Horse, N. J., under the joint cooperation of this Bureau and the New Jersey Department of Agriculture.

CONTROL OF PEACH MOSAIC AND PHONY PEACH DISEASES

Cooperative activities for the control of peach mosaic and phony peach were conducted with regular appropriations, emergency-relief allotments, and substantial contributions from the States. More than 16,400,000 orchard trees on 193,500 properties were inspected in 408 counties of 22 of the Southern States from the Atlantic to the Pacific. More than 104,000 diseased trees were found on 5,700 properties, almost 91,000 of which were destroyed. Trees infected with mosaic were found in 2 counties and trees infected with phony peach in 5 counties where these diseases had not been found before. Mosaic-infected trees were found in 37 counties in 7 States and trees infected with phony peach in 136 counties in 11 States. No trees infected with mosaic were found in 13 counties of 4 States and no trees with phony peach in 157 counties in 15 States where these diseases had previously been found to exist. Four entire States and 36 counties in 4 other States have qualified for removal from the phony peach quarantine status since 1936, 6 counties having qualified during the year.

Affected States have established quarantines to regulate the intrastate and interstate movement of restricted materials from regulated areas. The Bureau cooperates in the enforcement of such measures and during the spring of 1940 inspected 1,003 nurseries, growing over 24,000,000 peach trees, 144 budwood properties, and the environs within 1 mile of both nurseries and budwood properties. In the States where phony peach is known to occur, all but 3 nurseries met the certification requirements by removing, prior to June 30, all diseased trees found within 1 mile. In the area of the mosaic disease 131 nurseries and dealers failed to meet certification requirements and were prohibited from shipping peach or plum nursery stock. Fourteen budwood sources failed to meet the certification requirements because mosaic-infected trees were found either in the orchard or within 1 mile of it. Nurseries planning to use buds from these sources were immediately notified of the findings, and buds were obtained from other sources which met certification requirements. This action prevented 4 nurseries, growing over 274,000 trees, from securing buds from mosaic-infected sources.

More than 6,000,000 abandoned and escaped trees were removed, many possible sources of infection being thereby eliminated. All activities were conducted in close cooperation with the affected States.

CITRUS CANKER ERADICATION

Inspections for citrus canker were conducted in 11 counties in Texas and 18 parishes in Louisiana, with the assistance of State inspectors. Properties on which citrus canker had been found in previous years were intensively and repeatedly inspected, as were wild host plants and abandoned orchards. The activities in Texas were chiefly in 4 counties of the Galveston area, where canker has been found since 1935, and in the lower Rio Grande Valley. Citrus-growing nurseries of the Gulf coast area of Texas were also thoroughly inspected. No infections of canker have been found in or near any of these nurseries in recent years.

Louisiana State inspectors discovered citrus canker on one property in Jefferson Parish involving 804 trees, which were promptly destroyed. No canker has been found anywhere in Texas since September 1938.

The employment of relief labor in Texas under allotments from emergency relief appropriations made possible the removal and destruction of over 335,000 escaped and abandoned citrus trees, a large majority of which were *Citrus trifoliata.* The effectiveness of this type of work is indicated by the fact that, in reworking formerly infected properties, very few seedlings of these trees were found. This is encouraging in view of the difficulties experienced during previous years with recurring infections of canker on small seedlings of this species.

INSECTS AFFECTING FOREST AND SHADE TREES

PINE BARK BEETLES

There was no marked change in the amount of loss caused by bark beetles in the Western States. The outbreak of the Black Hills beetle in the Central Rocky Mountains that was so destructive during the period of 1935–39, as described in last year's report, has been reduced

to an endemic status in which only a small amount of maintenance control work is necessary. Conditions are not so encouraging in the Intermountain Region, especially on the Powell and Wasatch National Forests in Utah. Over 25,000 trees were treated by the Forest Service, part of the work being done by the penetrating-oil-spray method. Good results were obtained on the areas treated, but funds were not available to permit as complete coverage as would have been desirable. It is likely that additional work will be needed to bring this outbreak under control.

Losses caused by the western pine beetle increased in parts of California and southern Oregon, and several control projects were conducted by the Forest Service, the Office of Indian Affairs, and private timberland owners, following Bureau recommendations.

Field work on the hazard-inventory survey of the commercial ponderosa pine area in northeastern California was almost completed. This survey was based on the results of research in Oregon and California on the susceptibility of ponderosa pine to attack by insects, particularly bark beetles. Forest stands or areas have been given hazard ratings based on the history of their recent losses from insects and on the present condition of the individual trees. The most susceptible trees on the high-hazard areas may be marked for cutting. This will enable the owners to concentrate their logging operations in the areas where there is most danger of serious losses from bark beetles in the near future. The Forest Service and several large private operators in California and Oregon are making immediate use of the information supplied by the Bureau and are modifying their management plans to permit rapid and frequent coverage of their lands in an effort to take out susceptible trees before these are attacked by insects and rendered worthless.

EFFECTS OF LOW TEMPERATURES ON THE BLACK HILLS BEETLE

Laboratory studies to determine the effects of low temperatures on the Black Hills beetle are now completed. These studies, carried out during the last four seasons, show the range of temperatures fatal to this insect and reveal that the species is well adapted to survive the minimum temperatures of its normal distribution. Analyses of temperature records from standard weather stations in or adjacent to forests where epidemics have occurred indicate that killing temperatures occur approximately once in 7 years in the ponderosa pine type. Lethal low temperatures apparently occur less often in the limber and lodgepole pine types. Two instances of winter-kill of the Black Hills beetle are on record. Both of these occurred in Colorado, the first on February 1933, when an estimated mortality of 50 percent resulted from a low of −34° F., and the second in November 1938, when a 29-percent mortality was caused by a minimum of −15°. It is evident, therefore, that low temperatures constitute one of the factors of natural control. No example of field mortality sufficient to alter control projects is on record.

Experimental data of particular interest in connection with the foregoing conclusions are as follows: During October and November the cold hardiness of overwintering larvae increases very rapidly, reaching a maximum by mid-December. The larvae retain this maxi-

mum hardiness during the entire winter. In March resistance to cold begins to decrease and continues to do so until minimum hardiness occurs the first part of May. During the winter, larvae developing in lodgepole and limber pines will survive at air temperatures from 5 to 12 Fahrenheit degrees lower than those in ponderosa pine, but during spring and fall the cold hardiness of larvae in all three hosts is similar. In mid-October mortality of larvae removed from the bark of ponderosa pine begins at 10° and is completed at −1°. By mid-December, when the larvae reach maximum cold hardiness, mortality begins at approximately −13° and is complete at −31°. During May and June the hardiness is about the same as in mid-October.

CONTROL OF BARK BEETLES THAT TRANSMIT THE DUTCH ELM DISEASE

In connection with the Dutch elm disease project there has been some demand for a method that would protect elm wood from attack by bark beetles and other insects. Tests were conducted in which various materials were applied to the bark of elm logs. Treated and untreated logs were then placed in woodland where elms infested with various insects were present. Orthodichlorobenzene, monochloronaphthalene, or naphthalene, mixed with fuel oil or kerosene, were the most effective substances used. When applied in May they effectively repelled attack by the elm bark beetles *Scolytus multistriatus* (Marsh.) and *Hylurgopinus rufipes* (Eich.) and certain cerambycid beetles during the remainder of the year. Applied from September to April, inclusive, they reduced considerably the attack during the following season of insect activity.

Other experiments were conducted to test the value of various mixtures in killing the immature stages of *Scolytus multistriatus* and *Hylurgopinus rufipes*. The mixtures were sprayed on the bark of logs infested with the bark beetles. Twelve different combinations were effective when applied to logs that had become infested with beetles 3½ to 7 weeks previously. Variations in the moisture content of the bark had no apparent effect on the results of the treatments. The most outstanding feature of the experiments was the excellent results obtained with emulsified sprays in which water was used in place of fuel oil as a carrier for the lethal material.

An experiment was begun to determine the extent to which the population of the smaller European elm bark beetle (*Scolytus multistriatus*) can be reduced in a certain area by means of trap trees. Three woodland plots, each 2 miles square, in which elm trees are common were established. The elms in the areas were counted, their diameters at breast height recorded, and their locations indicated on maps. Two percent of the trees in the 6- to 8-inch diameter class were treated with sodium chlorate during the summer. Previous tests had shown that this treatment killed the trees and that they became specially suitable for bark beetle attack. From 6 to 7 weeks after treatment the trees were felled, barked, and appropriate notes made. All insect-infested material was then destroyed. The experiments will have to be continued in subsequent years to determine whether the bark beetle population can be satisfactorily reduced by chemically treating certain trees and destroying them after they become infested.

AMBROSIA BEETLES

Ambrosia beetles damage green logs and lumber, particularly of hardwoods, and their extensive tunnels and the stains caused by associated fungi constitute one of the most serious problems of the lumber industry in the Southern States. Logs and lumber may be reduced in value more than 50 percent within a few weeks. Chemical sprays for treating green logs and lumber have been tested in Louisiana since 1934, but satisfactory results were not obtained until 1939, when several chemicals gave consistent protection. Some of these also protected against sap stain. Unlike the simple chemicals used for controlling powder-post beetles, those effective against ambrosia beetles are complex but not too expensive; one is dichlorodiphenyl oxide, which is now being tested on a commercial scale in the Gulf States. A simpler method of preventing attack by ambrosia beetles is to end-rack lumber for 12 to 15 days. This will reduce the moisture content, which may be as high as 45 to 52 percent, to a point where ambrosia beetles will not attack.

Biological studies were begun at Saucier, Miss., in the spring of 1939. At the same time cooperative studies on the identity and biology of the associated stain fungi were instituted. Data on five species of ambrosia beetles in the genera *Platypus*, *Xyleborus*, and *Pterocyclon* indicate that, while there is considerable difference in habits, the most important species complete their life cycle in from 6 to 8 weeks in the Gulf States, and that the peak of activity is during July and August.

EUROPEAN SPRUCE SAWFLY

The European spruce sawfly is generally distributed throughout the spruce areas of New England and New York. During 1939 there was little change in its status over the entire region, but some of the severely affected areas increased considerably in size. In northern and eastern Maine there are heavy infestations in several townships, and in southern Vermont and southern New Hampshire heavy infestations increased in wide circles; so about 100 square miles are seriously affected in each of these two States. Up to the present there has been low mortality among trees severely defoliated by the sawfly. This is largely due to the fact that the larvae of the sawfly feed almost exclusively on the old needles, and enough of the current year's foliage remains to keep the trees alive. During 1939 an intensive study was undertaken to measure the sawfly populations causing various degrees of defoliation, the factors influencing these populations, and the effect of defoliation on the trees. Study plots were established in areas throughout the region where types of growth and climatic conditions differ considerably.

One of the outstanding developments during the 1939 season was the tremendous larval mortality caused by disease in areas where larvae were excessively abundant. As a result of this mortality there was a marked reduction in the infestation in such areas and a likelihood that little defoliation would occur there in 1940. From 10 to 60 percent of the overwintering cocoons were killed by mammals and predaceous insects. Several shipments of imported European parasites were received from Canada and liberated throughout

the infested area. Over 100 million adults of a gregarious cocoon parasite, *Microplectron fuscipennis* (Zett.), were reared by the States of Maine, New Hampshire, Vermont, and New York in cooperation with this Division and released throughout the infested region. This parasite has become established in many localities in the United States, and according to Canadian reports it is increasing rapidly in certain areas in New Brunswick.

DOUGLAS FIR TWIG WEEVIL

A recent widespread outbreak of the Douglas fir twig weevil (*Cylindrocopturus longulus* (Lec.)) in western Washington, involving conspicuous damage to young Douglas firs, called for an investigation, and a comprehensive study of the biology and life history of this weevil was concluded during the year. It was found that there was one generation a year, beginning with egg laying in green twigs from August 1 to September 15, but that the adults overwinter and lay fertile eggs the second season. Thirteen species of Hymenoptera were found to be parasitic on the weevil. Host resistance, competition among the larvae, and parasitism were considered as being the most important factors controlling the weevil population. It was concluded that this weevil is normally of minor importance on Douglas fir but that it may be a potential enemy of plantations, especially those on poor sites and gravelly soils.

DETERIORATION OF FIRE-KILLED DOUGLAS FIR

A study begun on the great Tillamook burn of western Oregon in 1933 to determine the role of insects as deteriorating agents and their influence on commercial salvage of the fire-killed Douglas-fir trees was brought to a close in 1939 when a second fire swept over a large part of this area and left few trees of the original burn intact. Where this second fire was especially hot, large numbers of wood-boring larvae were killed, but some broods of *Asemum* survived in the heartwood and deep in the sapwood of burned snags. From now on only the largest and best trees can be salvaged in the surviving logging operations, since wood borers, decay, and repeated burns have rendered unmerchantable the bulk of the original 10,000,000,000 feet of timber on this tract of 244,000 acres. This study has been of great value to the timber operators salvaging the fire-killed timber of the Tillamook burn and will be of further value to other logging operators who may be faced with similar problems in the future.

FOREST INSECTS IN PUERTO RICO

A preliminary survey of insect conditions in the forests and forest plantations of Puerto Rico was made in the spring of 1940. Insects were found to be the most important factor limiting the success of forestry operations in the islands, particularly with several of the most important tree species. For example, the cedro shoot borer (*Hypsipyla grandella* (Zell.)) has made it necessary for the Forest Service to give up attempts to use the valuable Spanish cedar in reforestation activities. Following the elimination of cedar, this borer appears to be rapidly increasing in plantations of mahogany. The aceitillo seed weevil (*Apion martinezi* Marshall) destroys about 98

percent of the seeds produced by the few remaining aceitillo or West Indian satinwood trees. The wood of this tree is very valuable, selling for as much as $90 per cubic foot. Most of the mature trees have been cut, and there is great difficulty in obtaining good seed for replanting.

Over 700 tree species of commercial value occur in Puerto Rico. Many of these are specially desirable for the manufacture of cabinets and furniture. There is, however, only a very limited supply of timber of merchantable size, and there is urgent need of replanting the more valuable species and giving them adequate protection against insects. The cost of forest products shipped into the Island in 1939 was approximately $4,750,000. A considerable proportion of these products can be grown locally if methods of controlling the insect pests can be devised. It is hoped that provision can be made in the near future for detailed studies of the important forest insect pests in Puerto Rico.

GYPSY AND BROWN-TAIL MOTH CONTROL

Considerable delay was experienced at the beginning of the year in resuming field operations on the gypsy-moth project, principally because of delay in the allotment of Work Projects Administration funds, and the work was not well under way until after September 1. The funds made available by the Work Projects Administration throughout the year amounted to $777,845, and the allotments were as follows: Vermont, $80,000; Massachusetts, $195,000; Connecticut, $120,000; New York, $100,000; and Pennsylvania, $282,845. This is a reduction of 18 percent from the funds allotted for the previous year. There was available from the regular Bureau appropriation $275,000 for control work in the New England States, New York, New Jersey, and Pennsylvania.

The reduction in funds, together with the decrease in administrative allotments, made it necessary to curtail salaried personnel, and 13 agents on the supervisory force were furloughed about the 1st of September. The requirement providing for the discharge of Work Projects Administration workers who had served for 18 months seriously affected not only the volume but the quality of the work, as experience is important in successfully carrying through many field details that are essential on this project. Limitation of expenditure of funds for nonlabor purposes also made it impossible to purchase essential supplies, particularly spraying materials and equipment of various kinds which are necessary for doing the work in a satisfactory manner. This caused a reduction in the volume of spraying, and it was impossible to treat some areas that should have received careful attention. The necessity of furnishing work within reasonable driving distance of the locations where men could be conveniently assembled also made it impossible to examine many areas that should have received attention in a systematic program of scouting, or to treat all infestations throughout the barrier zone.

Ninety-one percent of the Work Projects Administration funds were paid in wages to an average daily force of approximately 1,000 workers, and more than 98 percent of these were certified relief cases. In many of the industrial sections where unemployment had been par-

ticularly severe during the last few years conditions had improved, and the supply of unemployed men competent or physically able to perform good service was drastically reduced. There were many reasons for this, but an increase in industrial employment was one of the principal causes.

The weather was mild during the fall of 1939, but with the coming of the new year temperatures dropped drastically, and during the first few months heavy snow covered most of the area, particularly in the northern part. While the temperature dropped as low as −25° F. or lower in the northern part of the area and continued at low levels for rather prolonged periods, the eggs deposited the previous summer were not seriously injured. In the northern part of the territory hatching ranged from 50 to over 80 percent in Vermont, in Berkshire County, Mass., it averaged 90 percent, and in Connecticut, 96 percent. It was abnormally cool throughout April and May, and hatching in most areas was at least 2 weeks later than normal. Cool and inclement weather, accompanied in many sections by frost, caused heavy mortality among the small larvae. These conditions persisted for many days in June, so that in general the defoliation was not so heavy as it would have been in a normal spring. Owing to unusual rainfall an ample supply of water in small streams was available for spraying.

USE OF ATTRACTING CAGES IN LOCATING GYPSY MOTH INFESTATIONS

With the cooperation of the State officials concerned, attracting cages were placed in selected towns in the barrier zone in Vermont, in New York immediately west of the Hudson River, in northeastern New Jersey, and in Pennsylvania adjoining the outside border of the area that had been infested previously. A number of these cages attracted male moths, and during the fall and winter of 1939–40 the territory surrounding most of these attracting cages was scouted. Scouting at some was limited because the roads or trails were impassable during the winter and workers within reasonable distance were unavailable.

In Vermont 562 cages were put out in 11 towns, and 45 of these in 9 of the towns attracted 68 male moths. Scouting around the attracting cages located 32 infestations totaling 419 egg clusters in 4 of the towns where 32 cages had attracted 52 male moths. No infestations were found in the other 5 towns.

In New York 3,989 cages were put out in 35 towns, and 8 of these in 4 towns attracted 23 male moths. Scouting around the attracting cages located 2 infestations, 1 at Esopus of over 4,500 egg clusters and the other at the old Shawangunk infestation, where 305 egg clusters were found. At single attracting cages in 2 other towns no infestations were found.

In New Jersey 499 cages were put out in 6 townships and 2 small areas. Only 1 cage attracted a male moth. Scouting around the cage site did not result in the finding of any infestation.

In Pennsylvania 3,072 cages were put out in 21 townships, and of these 94 in 11 townships attracted 182 male moths. Scouting located infestations around all but a few of the attracting cages and resulted in the discovery of 64 infestations totaling 3,784 egg clusters, all of which were destroyed.

To summarize: 8,122 cages were put out in 73 towns, and of these 148 in 25 towns attracted 274 moths. The use of these cages, together with the scouting that followed, resulted in the discovery of 98 infestations totaling 9,008 egg clusters.

Owing to the delay in the return of W. P. A. labor to this project in the summer, it was possible to collect only 81,299 female pupae, from which 35,910 female moths emerged. This made possible the preparation of 1,197 charges of attractant, which were placed in cool storage for use in cages in the summer of 1940.

USE OF AUTOGIRO IN GYPSY MOTH WORK

Several tests were made in the summers of 1938 and 1939 to determine the feasibility of recording gypsy moth defoliation from the air. For this purpose an autogiro with two seats for observers in addition to the pilot is preferable, but feeding of 25 percent or less cannot be recorded. For this work men must be employed who have had experience in estimating defoliation, and it has been found difficult to carry on with a reasonable degree of accuracy with men unaccustomed to flying and making records of this type on maps. Work done thus far has been checked in the same territory by the usual methods of estimating from the ground, but it has not been possible as yet to determine whether a saving can be made by using an autogiro for this purpose.

During the summer of 1939 defoliation ranging from slight to complete covered 492,640 acres, which was a substantial increase over the acreage recorded in the summer of 1938. There was some increase in Maine, New Hampshire, and Vermont, slight decrease in Massachusetts and Rhode Island, and an increase in Connecticut west of the Connecticut River. In the entire territory between the Connecticut River and the barrier zone defoliation was slightly less than the previous year. No defoliation was recorded in the barrier zone or in New York, New Jersey, or Pennsylvania.

During June 1940 two areas in Connecticut aggregating 460 acres were treated with a combination of lead arsenate and fish oil which was applied from a specially designed distributing apparatus built into an autogiro. This work was done in the towns of Granby and Simsbury, in cooperation with the State entomologist and the Division of Control Investigations of this Bureau. It demonstrated that good distribution of the poison can be accomplished in this way, but complete results will not be available until the areas treated have been finally checked after the foliage is down.

SCOUTING AND TREATMENT FOR THE GYPSY MOTH

Scouting resulted in the discovery of many small, scattering infestations in the Massachusetts and Connecticut portions of the barrier zone, in the southern part of Bennington County and sections of Rutland and Addison Counties in Vermont, and in several New York towns in the region of the Massachusetts State line. The indications are conclusive that these infestations became established by wind spread of small caterpillars from infested areas to the east of the zone in the spring of 1939, and to some extent at least from fragments of egg clusters dislodged from tree growth during the hurricane of September

1938 and carried into the zone on the high-velocity, rotating air currents prevalent at that time. Because of this unusual and decidedly abnormal wind spread, approximately one-half of the total zone area should be scouted and treatment applied within the next year or two so as to insure the continued satisfactory maintenance of the zone in its present location. From intensive scouting work this year at sites of infestations discovered in the New England barrier zone area, in New York, and in Pennsylvania, during the fiscal year 1939, it was determined that 99 infestations have been exterminated. Of this total 15 were exterminated in Vermont, 7 in Massachusetts, 17 in Connecticut, 30 in New York, and 30 in Pennsylvania. There has been a marked reduction in egg clusters at numerous other infested sites.

Infestations found in Princeton and Calais in Washington County, Maine, in 1938 and 1939, respectively, were intensively scouted in the fall of 1939 by two experienced employees. As no evidence of the gypsy moth was found, these infestations are considered exterminated. Helpful cooperation was maintained with the Dominion of Canada Division of Production and with the Province of New Brunswick and local authorities in St. Stephen across the border from Calais, Maine, where a small infestation of the gypsy moth is being treated.

With the exception of a very limited amount of work in territory adjacent to the zone in Rutland County, work in Vermont was confined to the barrier zone, principally north of Rutland. As nearly all the cages that attracted male moths were located in Addison County, it was planned to expend a large proportion of the available funds there this year. Scarcity of relief labor in that county, however, made it impossible to secure a sufficient force to effect satisfactory progress. Unfortunately the State-wide rate was not authorized for W. P. A. gypsy moth work in Vermont, therefore workers from bordering counties receiving a higher rate could not be used in Addison County without specific authority from the W. P. A. Late in the year authority was secured from the State Administrator to employ a small force of Rutland County workers in southern Addison County, but this could not be done until the workers had been reclassified to the Addison County rate. As this rate was much lower than was paid workers employed in Rutland County, many of the men soon became discouraged and left. For this reason, and also because of a serious shortage of certified relief labor in Addison County, much urgently needed work in dangerous territory could not be done. Two high-powered sprayers were used during June on the single-shift 8-hour-day basis in spraying infestations discovered during the year in Bristol and Middlebury, Addison County.

Work in Massachusetts was confined to the barrier zone, comprising all of Berkshire County, the town of Monroe in Franklin County, and limited areas on high elevations adjacent to the zone in Franklin, Hampshire, and Hampden Counties. As stated, numerous scattering egg clusters were discovered in the zone, so distributed as to indicate conclusively that they had become established as a result of the wind spread of small caterpillars in the spring of 1939, and to some extent by fragments of egg clusters dislodged from trees and carried into the zone by winds of high velocity during the hurricane of September 1938. Similar conditions were reported by the New York Conservation Department in towns adjacent to the Massachusetts line

in Rensselaer County, N. Y. Territory under suspicion should be scouted within the next year or two so that infestations existing there may be located and exterminated before spread from them occurs. Seven heavy-duty sprayers, operated on the double-shift basis of 6 hours for each shift, were used during June in spraying the most serious infestations discovered in the Massachusetts zone area during the year.

Except for a small amount of selective thinning at the site of an infestation in West Hartford, Hartford County, all scouting and treatment work in Connecticut was confined to the barrier zone, particularly in Litchfield County. Because of the wind spread in the fall of 1938 and spring of 1939 previously referred to, conditions, at least in the northern portion of the Connecticut zone area, are about the same as in Berkshire County. In addition to this abnormal wind spread, infestations established several years ago in northern Litchfield County towns are gradually increasing because scarcity of relief labor for W. P. A. assignment and lack of regular funds for the employment of per diem labor make it impossible to do urgently needed work. Good progress has been made in eradicating the isolated infestation found last year in Southbury, New Haven County. A small infestation in the city of New Haven reported by the Connecticut Agricultural Experiment Station this spring has been intensively scouted, and treatment, including spraying, has been applied. Eight heavy-duty sprayers, two of which were operated by a force of C. C. C. workers detailed from Camp Cross in Sharon, were used in the Connecticut barrier zone in June in treating the most serious infestations found during the year. Although all these sprayers began work on the double-shift basis of 6 hours for each shift, resignations in the W. P. A. force made it necessary after the first week to operate three of the machines on the single-shift basis of 8 hours.

Federal W. P. A. forces, Civilian Conservation Corps camp enrollees, and State employees supervised by the New York Conservation Department scouted and applied necessary treatment in areas considered most dangerous in Rensselaer, Columbia, Dutchess, and Putnam Counties within the zone and in Essex, Warren, Saratoga, Albany, Ulster, Rockland, Westchester, and Nassau Counties to the west and south of the zone. Although numerous scattering infestations resulting from the wind spread previously mentioned were found in a strip of towns paralleling the Massachusetts State line in Rensselaer and Columbia Counties, all were small and many no doubt have already been exterminated. Considerable additional work is needed in these two counties to complete the area and locate and treat any existing infestations. In spraying the most serious infestations discovered during the year the New York Conservation Department used 11 machines, 6 of which were temporarily loaned by this project, as they were badly needed in treating areas in that State and a sufficient supply of lead arsenate was not available for them to be operated by this project.

Although no Federal gypsy moth work was carried on in New Jersey during the year, a small force of State employees scouted intensively at the site of an attracting cage in Englewood Boro, Bergen County (near George Washington Bridge), where a male

gypsy moth was taken in the summer of 1939. These men also examined selected areas in Middlesex, Morris, Passaic, Somerset, Sussex, and Warren Counties. A total of 6,706 acres of woodland and more than 33,750 fruit and shade trees were examined. No evidence of the gypsy moth was found.

Work in Pennsylvania was confined chiefly to sections of the centrally infested area not scouted last year and to intensive scouting and necessary treatment at sites of infestations previously located in lightly infested territory and similar work at sites of assembling cages where moths were taken in July and August 1939. In scouting the lowlands along the Susquehanna and Lackawanna Rivers lying within the infested area, 1 infestation consisting of 58 egg clusters was located and treated in the township of Pittston. Spraying of the infested residential areas was begun May 21 and 2,351 individual properties were treated. Fifteen of the 28 sprayers used in woodland spraying, which was begun on June 3, were operated on the double-shift basis and the remaining 13 machines were operated throughout the season on the single-shift basis of 8 hours' daily employment.

In October and November 1939, federally supervised gypsy moth projects using labor furnished by the National Youth Administration began operations in Luzerne and Lackawanna Counties, Pa. Together these projects provided for the monthly employment of 320 workers. These workers were divided into 3 groups for each county and were furnished 48 hours of employment each month. Although considerable difficulty was experienced with these men at the beginning of the work, this was gradually overcome and much good work was done, although close supervision by thoroughly experienced regular employees was necessary at all times. Beginning in December, 9 workers employed on the basis of 3 equal shifts monthly were detailed to work in the repair shop at Wilkes-Barre.

In October a Department of Public Assistance project sponsored by the Bureau of Plant Industry of the Pennsylvania Department of Agriculture was started in Pittstown Township, but the project was disappointing because it was found impossible to obtain a sufficient number of workers willing and qualified to do the work assigned them. In May 1940, when this project was terminated, less than 43 percent of the man-hours of labor promised in the project application had been furnished. Worthless brush and debris on the forest floor of 217 acres was cut and disposed of by these workers during their period of employment.

In the enforcement of the Pennsylvania quarantine on account of the gypsy moth, 16,089 shipments from the lightly infested area were allowed to move on permits issued after it had been determined that there was no danger of transporting infestation. In the generally infested area 19,029 shipments were thoroughly inspected before certificates were issued authorizing them to be moved. Sixty-one warnings were issued to first-time violators of the quarantine, and there were 3 individual instances of the successful prosecution of shippers who failed to heed the warnings issued to them. Effective November 15, 1939, a Pennsylvania State quarantine revision eliminated quarantine restrictions on the townships of Canaan in Wayne County, Carbondale in Lackawanna County, and Jackson in

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Luzerne County. This quarantine revision and the extermination of 30 infestations in the lightly infested territory were the outstanding accomplishments of the year in the Pennsylvania area, and these, together with a progressive reduction in the severity of infestation throughout the territory covered by this project, very definitely indicate that progress is being made in eradicating the gypsy moth from that State.

GYPSY MOTH WORK BY CIVILIAN CONSERVATION CORPS

The Bureau has continued to cooperate with the United States Forest Service and State C. C. C. officials in supervising C. C. C. gypsy moth work in towns just east of the barrier zone in Vermont, Massachusetts, and Connecticut. This has been done as in the past to discover and treat, insofar as this is possible with available crews, gypsy moth infestations that were the most threatening to the barrier zone. This has been helpful to the zone and to the towns where it was done, but there are strategic places just east of the zone where work is needed but no enrollees are available.

The quota of C. C. C. enrollees available for this work previous to the hurricane of 1938 has never been returned to this project.

During the year 70,630 6-hour C. C. C. man-days were furnished for the work but, based on the allotment available at the time of the hurricane, 51,817 additional 6-hour man-days that were taken from it and used on fire-hazard-reduction work should have been available. At the beginning of the year aproximately 167 enrollees were available from 5 camps in Massachusetts and Connecticut, but none from camps in Vermont. During the year there were some changes in camp locations and personnel, and men became available at 2 camps in Vermont, 4 in Massachusetts, and 4 in Connecticut. In the spring the gypsy moth camp at Greenfield was discontinued and the camp previously removed from Westfield for work necessitated by the hurricane was returned to that location. In Connecticut a crew at 1 camp has never been returned to the work and at another camp a crew which was available for part of the year was removed to do gypsy moth thinning work under the direction of the State forester.

As a result of this work slightly over 129,000 acres were examined, approximately 23,000 of which were given open-country scouting and 1,700 were thinned. Egg clusters to the number of 1,496,305 were destroyed by creosoting and burning. In addition, 266,458 trees were burlapped, and men patrolling the burlap bands destroyed 311,454 gypsy moth caterpillars and pupae. Work was done in 41 towns in Vermont, Massachusetts, and Connecticut.

The Bureau loaned seven spraying machines for C. C. C. use east of the barrier zone in Massachusetts and Connecticut. The State entomologist of Connecticut furnished two machines for this work.

The C. C. C. purchased lead arsenate and fish oil for use in Massachusetts and Connecticut, as well as the labor for this work. All the machines excepting one in Massachusetts were used on a double-shift basis. A total of 2,816 acres of woodland were sprayed.

The work has resulted in a great decrease in gypsy moth infestation in the area between the Connecticut River and the barrier zone in Massachusetts and Connecticut. Those areas which were

given intensive treatment a year ago are in excellent condition at this time insofar as infestation is concerned. The infestation in the Connecticut River Valley towns in the southern half of Vermont has persisted and only a small amount of work has been done there since the hurricane of 1938. Large areas in the towns of Putney, Westminster, Rockingham, and Springfield were severely defoliated during the summer of 1940.

Examination of areas in Connecticut and Vermont where severe defoliation occurred a year or two ago shows considerable mortality of oaks, white pine, and hemlock.

Table 5 gives a numerical summary of scouting and treating done by the Bureau during the year.

TABLE 5.—*Gypsy moth control work, fiscal year 1940*

State	Project	Scouting							Thinning		Fencing		Banding			Spraying		
		Open country scouted					Woodland scouted	Egg clusters creosoted	Woodland thinned	Trees cut in open	Erected	Removed	Burlap bands applied	Pupae crushed	Larvae crushed	Woodland sprayed	Residential properties sprayed	Trees in open sprayed
		Open areas scouted	Roads	Apple trees	Oak trees	Shade trees												
		Acres	*Miles*	*Number*	*Number*	*Number*	*Acres*	*Number*	*Acres*	*Number*	*Feet*	*Feet*	*Number*	*Number*	*Number*	*Acres*	*Number*	*Number*
Maine	Regular	600	3	300	5	7,750	0	0	0	0	0	0	0	0	0	0	0	0
Vermont	W. P. A. and regular	112,214	554	99,387	11,441	222,627	123,989	547	40	0	26,327	59,340	10,305	30	241	306	0	0
	C. C. C	4,101	42	10,760	40	6,760	20,242	344,988	464	722	0	0	35,295	0	22,535	0	0	0
Massachusetts	W. P. A. and regular	58,120	676	87,544	5,680	117,795	129,502	25,082	509	598	43,625	298,710	114,944	82,219	5,598	1,474	0	30
	C. C. C	8,516	133	23,250	10,942	21,044	42,446	289,018	512	481	38,280	0	114,398	57,630	220,863	1,243	0	80
Connecticut	W. P. A. and regular	45,371	346	63,347	25,103	110,568	40,428	23,813	125	530	89,442	0	181,919	54,965	64,548	1,492	15	166
	C. C. C	10,856	128	34,428	11,222	50,960	39,969	[1] 862,299	707	2,619	43,560	0	116,765	1,727	8,699	1,573	0	25
New York	W. P. A	43,730	494	136,957	99,544	490,670	59,036	2,415	270	20	34,820	0	[2] 34,814	0	14,816	627	0	0
	State and C. C. C	310,891	2,954	562,160	0	4,042,014	182,532	3,890	411	0	0	0	[2] 75,476	0	4,921	566	0	0
Pennsylvania	W. P. A. and regular [3]	36,217	529	96,927	25,775	327,860	85,132	59,192	245	7	87,240	86,852	514,178	15,013	65,264	4,861	2,351	39,280
Total	W. P. A. and regular [4]	607,143	5,556	1,046,622	167,548	5,319,284	620,619	114,939	1,600	1,155	281,454	444,902	931,636	152,227	155,388	9,326	2,366	39,476
	C. C. C. [5]	23,473	303	68,438	22,204	78,764	102,657	1,496,305	1,683	3,822	81,840	0	266,458	59,357	252,097	2,816	0	105
Grand total		630,616	5,859	1,115,060	189,752	5,398,048	723,276	1,611,244	3,283	4,977	363,294	444,902	1,198,094	211,584	407,485	12,142	2,366	39,581

[1] 720,950 estimated egg clusters burned in debris assembled included in Connecticut figure.

[2] A large percentage of the bands applied in New York were of sticky material instead of burlap.

[3] Also includes work performed by N. Y. A. and Department of Public Assistance workers.

[4] Includes State and C. C. C. work in New York.

[5] Not including C. C. C. in New York.

GYPSY AND BROWN-TAIL MOTH QUARANTINE ENFORCEMENT

CERTIFICATION OF QUARANTINED PRODUCTS

Continued heavy infestations of the gypsy moth in sections of the generally infested area again resulted in an increase in the number of egg masses and other stages of the insect removed during routine inspections of quarantined products. Total shipments certified numbered 98,302. This represents a 16-percent increase in the volume of inspection work. From these shipments there were removed and destroyed 3,403 egg clusters, 303 larvae, and 133 pupae. The most heavily infested shipment inspected was a carload of lumber inspected at Madison, N. H., prior to movement to Rochester, N. Y. Three hundred and thirty-seven egg clusters were removed from the boards in this shipment. There was no change in the quarantine regulations as previously revised effective September 29, 1938.

On December 7, 1939, the district field office supervising the enforcement of the gypsy and brown-tail moth quarantine was removed from the customhouse in Boston to 144 Moody Street, Waltham, Mass.

A long-continued dry spell late in the summer and cold weather, snow, and an unusual amount of frost in the ground during March and April hampered nursery shipments during the fall and spring shipping seasons. This was the first season on record that spring digging was so long delayed over the entire New England area. Cool rainy weather continued into May, permitting continuance of digging operations during the entire month.

Eleven temporary inspectors were added to the inspection force during October in Connecticut and Massachusetts. Their principal assignment was the inspection of nursery stock going into winter storage. Thirty-three temporary inspectors were employed in connection with the inspection of nursery products during April. Nine of these were stationed at a forest nursery in Maine to inspect 2,000,000 young trees.

Inspection of nursery stock at one of the nurseries in the Middletown, Conn., area resulted in the finding of two gypsy moth egg clusters. Prior to the fall of 1939, permits had been issued to this establishment and those in the immediate vicinity, on the basis of their freedom from gypsy moth or Japanese beetle infestation. When egg clusters were found on one of the establishments in this nursery center, all nursery permits in that section were suspended. Five egg clusters were removed from nursery stock offered for inspection by one of these nurseries during the spring shipping season.

From 25,448 shipments of nursery stock certified during the year there were removed 39 egg clusters and 1 pupa. Classes of nursery products inspected were as follows:

	Number
Shrubs	3,068,366
Specimen trees	26,422
Young trees	160,035
Specimen evergreens	468,229
Young evergreens	4,386,654
Seedlings, cuttings, and small plants	2,533,734
White pine trees	340,584

A combination of increased business and ideal weather conditions during the Christmas tree cutting and inspection season, November 1 to December 23, contributed to an increase in the quantity of

trees inspected as compared with the previous season. This year 448,246 Christmas trees were inspected in the lightly infested gypsy moth area. This was a 30-percent increase over 1938, when 344,066 trees were similarly certified. Only 1 egg cluster was removed from a Christmas tree in connection with this year's inspection activities.

Five hundred and seventy-two egg clusters and 7 pupae were removed from 22,236 lots of miscellaneous evergreen products inspected. Segregated as to classes, these shipments comprised—

Boughs, balsam twigs, and mixed greens	boxes or bales	43,187
Laurel	do	7,102
Miscellaneous	boxes, bales, pieces	5,702
Do	yards of roping	17,900
Do	truckloads	6

Further tests were made with grinding machines used in producing sawdust. Certification was granted for sawdust produced by mills using machines that destroy eggs on shavings fed into the grinders. Preliminary tests were run to determine the toxicity of methyl bromide on gypsy moth egg clusters. If this proves practicable, a method of fumigation of heavily infested products will be devised.

Large quantities of lumber salvaged from trees felled by the hurricane of September 1938 were inspected and certified for movement to noninfested States. There were certified during the year 32,847 shipments of forest products. From these, 2,781 egg clusters, 219 larvae, and 125 pupae were removed. Products in this classification certified during the year were as follows:

Barrel parts, crates, crating	cases, bundles	31,247
Logs, piles, posts, poles, ship knees, and ties	pieces	423,655
Fuel wood	cords	10,191
Pulpwood	do	33,652
Miscellaneous wood	do	212
Lumber	board feet	61,480,446
Empty cable reels	number	45,257
Shavings	bales	100,891
Shrub and vine cuttings	boxes	7,737
Lags	bundles	8,137
Miscellaneous	pieces	256,546
Do	carloads	66
Do	bundles, bags, boxes	14,841
Do	tons	1,155
Do	truckloads	5

Stone and quarry products comprising 17,771 shipments were examined. From these there were removed 10 egg clusters and 84 larvae. The products included in these shipments were as follows:

Crushed rock	tons	201,469
Curbing	running feet	39,667
Feldspar	tons	1,730
Granite	pieces	139,537
Do	tons	20,619
Monumental stone	pieces	17,386
Grout	tons	4,574
Marble	pieces	357
Paving blocks	number	219,578
Miscellaneous	pieces	11,610
Do	tons	1,153
Do	carload	1

During the year investigations were made of 952 apparent violations of the gypsy and brown-tail moth quarantine.

DUTCH ELM DISEASE ERADICATION

GENERAL STATUS

Activities during the year disclosed a 49-percent reduction in the number of trees found to be infected with *Ceratostomella ulmi*, the fungus causing the Dutch elm disease, as compared with the preceding year. Intensive scouting in sections where heavy concentrations of the disease or dense infestations of the bark beetle carriers of the fungus occurred in the summer of 1938 showed uniform reductions in confirmations in these areas. With a few comparatively unimportant exceptions, this same condition was found throughout the main region in which the disease is discontinuously scattered.

There was a still further reduction this year in the number of cases discovered at outlying points. Of 16 confirmations reported from States outside the major disease area, 9 were in the Indianapolis, Ind., area, 6 in Athens County, Ohio, and 1 in Cumberland, Md.

Results of the eradication work in Indianapolis were encouraging, evidencing the benefits of the extensive elm-sanitation campaign performed in that section. The only extension of area there was in a section about 1½ miles to the northwest. There was no recurrence of the disease in the original Brightwood area. Only one diseased tree was found in each of the three previously located heavily infected centers in Indianapolis. One of the diseased trees in the Athens area was found at a new infection center at Hockingport, at some distance from the other infections in the county. The Cumberland tree was the first confirmation in Maryland since 1936. No reappearance of the disease was observed in the other isolated cities where small numbers of infected trees had been destroyed in earlier years.

Regulations supplemental to quarantine No. 71 continued in force. The regulations were amended, effective September 11, 1939, to include in the area infected by the Dutch elm disease additional townships in Connecticut, New Jersey, and New York. Federal quarantine action was withheld in the case of the Pennsylvania infected zone, since the State placed an embargo on the movement of elm material therefrom. This action continued the Federal embargo on the movement of sources of infection from heavily infected sections of New Jersey into Pennsylvania, where infection is limited.

SYSTEMATIC SCOUTING

Foremost among the newly discovered main-area infections this year was the disease center found in 6 towns just east of Binghamton, Broome County, N. Y. This is approximately 70 miles from the main disease zone and is being handled as a separate area. Otherwise in New York the infection zone was rounded out by the finding of diseased trees in many of the Dutchess, Orange, and Ulster County towns intervening between detached infections discovered in previous years. First-record cases were found in a few towns in Litchfield and New Haven Counties, Conn., east and north of previously known infected territory in that State. As scouting progressed in the remainder of Bucks County, Pa., further incursions of the disease were found in most of the townships and in a few adjoining townships in Lehigh and Northampton Counties. A few diseased trees were found in several townships in Monroe County, Pa., bordering the

Delaware River. The southernmost infection thus far found in the main area was discovered in ward 35 of Philadelphia County, Pa., just across the line from Bucks County. Extension of the New Jersey infected zone was limited to two townships in Burlington County and a single township in Monmouth County, contiguous to the previously established infected area.

Systematic scouting was already under way at the beginning of the year, having been organized on June 12. Owing to exhaustion of funds it was necessary to terminate, beginning August 19, the per diem scouts paid from the regular Departmental appropriation. The continuity of employment of these per diem scouts permitted an organization of the work previously impossible with the comparatively stable W. P. A. crews. To intensify the scouting during the most favorable weeks for observation of disease symptoms, the men worked six 8-hour days per week, with monthly work periods of 208 hours, as contrasted with the short monthly work period of 130 hours for W. P. A. workers. Of distinct advantage was the mobility of the per diem scouts, permitting transfer of scouts between counties and between States as the exigencies of the work required. Training of more than a thousand well-qualified scouts and foremen, many of whom will be available for scouting next season, was in itself a major contribution to the eradication work in future years.

There were several interruptions in the scouting activities by W. P. A. workers. Pending an allotment of funds, all security-wage workers were laid off from 3 to 10 days at the beginning of July. At the end of the August work period approximately 40 percent of the W. P. A. scouts were dismissed under the law which terminated employment of all security-wage workers who had been continuously employed for 18 months. A W. P. A. scouting force averaging 900 men was left to finish the season.

During the important months of July and August the total force assigned to scouting averaged 3,400 and 3,000, respectively, an increase of 700 men over the same months in 1938.

Systematic summer scouting in the States of Connecticut, New York, New Jersey, and Pennsylvania during the preceding year totaled 15,127 square miles on all surveys. This year's coverage was boosted to 25,458 square miles, a 68-percent increase. Another criterion of the effectiveness of the 1939 scouting in revealing the present status of the disease is the number of trees that warranted sampling while symptoms were most apparent and the combined W. P. A and per diem scouting force was at its peak efficiency. Samples collected during June, July, and August of 1939 totaled 69,641, an increase of nearly 8,000 over the same period of 1938. Notwithstanding this increased sampling, the number of trees confirmed as infected was substantially reduced from the 1938 figure. Total confirmations during the period June 1 to September 30, 1939, numbered 9,851, as contrasted with the 1938 total of 15,935. There were reductions of 136, 6,155, and 14 cases, respectively, in Connecticut, New Jersey, and States outside the major zone of infection. Comparative increases were limited to 34 trees in New York and 187 cases in Pennsylvania. These nominal increases despite considerable extension of area in both New York and Pennsylvania indicate the moderateness of this year's infection in these two States.

Summer scouting in 1939 was the most extensive ever undertaken. It included a complete first survey and a 60-percent second coverage of the major disease area, approximately the extent to which the known infected zone was covered in 1938. One complete coverage and an approximate 70-percent completion of the second survey was accomplished in the protective zone circumscribing the major disease area. These two areas, including roughly the territory within a 70-mile radius of New York City, comprise the work area to which systematic scouting was confined in previous years.

Beyond the confines of the work area as defined in previous years, scouting during 1939 was expanded to include advance survey work in the sector between the 70- and 100-mile radius lines from New York City. This area was given one complete go-over, with 67-percent completion of a second survey. The results were negative.

Still more remote from the main area of infection was an extension survey in the territory lying between the 100- and 150-mile circumferences. This was of an exploratory nature to determine what could be found beyond the advance survey area by very light scouting. It resulted in the finding of the diseased trees in the Binghamton, N. Y., area.

Autogiro scouting of approximately 4,500 miles of railroad rights-of-way was repeated during the summer, again with negative results. Southern railroads from Norfolk to New Orleans were omitted from this year's program, since repeated surveys of these lines failed to link any southern States with the Dutch elm disease. Ground crews associated with the flying units found infestations of *Scolytus multistriatus* (Marsh.) in the western part of Pennsylvania, and confirmed reports of the presence of this species at Columbus, Ohio, and Rochester, N. Y.

Scouting in the isolated infected regions was both timely and thorough. Previous years' elm-sanitation activities in these areas facilitated the surveys in the environs surrounding Indianapolis, Ind.; Athens, Ohio; Cumberland, Md.; and adjoining West Virginia and the Potomac Valley.

During the year 72,781 samples of elm wood suspected of containing the elm-disease fungus were submitted to the laboratory for culturing and determination. From 9,189 of these samples *Ceratostomella ulmi* was cultured. Segregated as to location, 368 confirmations were in Connecticut, 7,501 in New Jersey, 1,088 in New York, 216 in Pennsylvania, and 16 at the several isolated infections.

Wilting and discoloration characteristic of Dutch elm disease infection were first found in the spring of 1940 on May 18, in Connecticut. General wilting of elm foliage was observed early in June.

Since discovery of this disease in the United States in 1930, a grand total of 57,400 elms have been confirmed as infected. Of this total, 1,339 were in Connecticut, 45,152 in New Jersey, 10,470 in New York, 262 in Pennsylvania, and 177 in the localized infection centers in States remote from the major infected regions. The accumulative total of 177 cases at the isolated infections comprises the following: 113 in Indianapolis, Ind.; 2 in Baltimore, 3 in Brunswick, and 2 in Cumberland, Md.; 12 in Athens, 1 in Cincinnati, and 33 in Cleveland, Ohio; 5 in Norfolk-Portsmouth, Va.; and 6 in Wiley Ford, W. Va.

During June approximately 1,000 qualified W. P. A. workers were assigned to scouting. Activities during the month were limited to the main disease area and to the work areas in Indianapolis, Athens, and Cumberland. By the end of June about 5 percent of the major disease area had been covered by systematic foot or automobile-foot scouting. In the remainder of the main area automobile scouting was performed at about 10 times the rate of systematic foot scouting.

EXTENSIONS OF WORK AREA

As a result of further discoveries of elms infected with the disease fungus in or beyond the border-zone scouting area surrounding the known infected area, 74 towns, townships, boroughs, cities, and wards were added to the infected zone. These were as follows: In Connecticut, the towns of Shelton and Trumbull in Fairfield County, Litchfield and Woodbury in Litchfield County, and East Haven, Hamden, Milford, North Haven, Oxford, Seymour, Southbury, Wallingford, and West Haven in New Haven County; in New Jersey, the townships of Chesterfield and Mansfield in Burlington County and the township of Manalapan in Monmouth County; in New York, the towns of Colesville, Fenton, Kirkwood, Sanford, and Windsor in Broome County, Afton in Chenango County, Ancram and Livingston in Columbia County, Amenia, Beekman, Dover, Milan, Northeast, Red Hook, Rhinebeck, and Unionvale in Dutchess County, Crawford, Montgomery, Mount Hope, and Walkill in Orange County, Kent in Putnam County, and Gardiner, Lloyd, Marbletown, Marlborough, New Paltz, Plattekill, Rosendale, Shawangunk, and the city of Kingston in Ulster County; in Ohio, the township of Troy, Athens County; in Pennsylvania, the townships of Bedminster, Doylestown, Durham, East Rockhill, Haycock, Middletown, Milford, New Britain, Newtown, Northampton, Plumstead, Richland, Springfield, Warrington, Warwick, West Rockhill, and the borough of Yardley in Bucks County, the towns of Salisbury and Upper Saucon in Lehigh County, Middle Smithfield, Smithfield, and Stroud in Monroe County, Hanover, Lower Saucon, and Williams, and the borough of Hellertown in Northampton County, and Ward 35 in Philadelphia County.

In the course of the year's scouting and elm-sanitation activities 1,619 square miles were added to the infected zone, with a corresponding reduction of 828 square miles in the border-zone scouting area. The major disease area at the end of the year included 948 square miles in Connecticut, 3,449 in New Jersey, 3,642 in New York, and 760 in Pennsylvania, a total of 8,799 square miles. The border-zone scouting area comprised 341 square miles in Connecticut, 772 in New Jersey, 995 in New York, and 703 in Pennsylvania, totaling 2,811 square miles. The entire zone of field operations totaled 11,610 square miles, an increase of only 790 square miles.

ERADICATION AND SANITATION ACTIVITIES

Special attention was given during the winter of 1939–40 to increasing the effectiveness of the elm-sanitation work by limiting tree removals to elms already attacked by bark beetles and by including the removal of parts of trees that were potential breeding places

for such bark beetles. This is contrasted to earlier work that emphasized the removal of all elms over 50 percent dead and excluded the pruning of branches. More attention was given this year to the destruction of wood piles and slash. Fifteen illustrations were prepared describing elm wood considered easy prey for bark beetles as well as wood not likely to be attacked by beetles. Using these illustrations, supervisors gave field crews special training in the recognition of wood involving the greatest hazards. An analysis of the results obtained showed that, with thorough elm sanitation as an objective, 95 percent of all beetle-infested material could be destroyed in 80 percent of the time required in the absence of this type of training. In areas where manpower was so limited that a thorough job could not be attempted, it was possible to remove 80 percent of all beetle-infested material and 10 percent of the material that might become infested in 30 percent of the time that would have been required to carry on the sanitation program of previous years.

The selective removal of such material was found to be of further advantage during the spring and early summer of 1940, when most of the work area was rechecked to remove infested material before beetle emergence. This work was largely limited to removal of the five categories of beetle material considered the most dangerous. These five classes largely comprise beetle-susceptible material resulting from wilt diseases and mechanical damage, such as breakage, girdling, and cutting. Trees slowly dying as a result of unfavorable soil conditions were found to be only slightly attacked by bark beetles seeking breeding places.

A further advantage of this revised program is that it is possible to destroy dangerous beetle-infested and susceptible material in certain trees by pruning and thus save the tree if it is otherwise a desirable or valuable one. Owners of trees have been much more willing to grant permission for sanitation work when this has been explained to them.

During the year field workers eradicated and removed 9,864 elms confirmed as infected, 206,540 elms in the sanitation program, and 56,428 elms in selective operations, a total of 272,832. The grand total of trees removed in all operations in the preceding year was 773,604. A reduction in the W. P. A. personnel during the winter accounted for the decrease. At the end of the year a grand total of 5,576,680 elms had been removed as a result of the various types of operations practiced since 1933. There remained standing at the end of the year 180 diseased trees.

Selective-cutting operations were performed in the vicinity of Cumberland, Md., to eliminate the elm population in territory formerly scouted with considerable difficulty. Isolated groups of elms of low value in rough, mountainous terrain were located and later removed. Also in Maryland, the removal of beetle-infested elm wood, wood furnishing potential breeding places for bark beetles, and dead and dying elms was completed within a radius of 4 miles of the solitary Maryland confirmation. Destruction of wood susceptible to infestation was carried on throughout the winter in the West Virginia work area. In Ohio clear-cutting of elms was accomplished wherever permissions could be obtained for this type of work in the localities where six disease cases were found during the year. Removal of

beetle-infested wood and that susceptible to infestation was carried on in the Indianapolis work area during the winter.

An ice storm on the night of March 3 and the morning of March 4 caused widespread damage to elms in large sections of the infected zone. In some sections this damage approached or exceeded that done by the hurricane of September 1938, particularly insofar as the production of elm wood subject to elm bark beetle attack is concerned. The principal damage by the hurricane was the blowing down of entire trees. The ice that collected on the trees during the ice storm, however, broke off large branches and left many hanging that had to be removed before spring emergence of elm bark beetles. Ice coated the trees so thickly that in sections severely affected there was scarcely an elm in which there were not one or more "hangers." The emergency situation resulting from the ice storm made it necessary to deviate from the regular work program. In some sections the storm left more material susceptible to infestation than existed in the work locations before elm-sanitation work was begun. In the town of Ridgefield, Conn., for example, a survey showed that 100 men would be required for a year to remove and dispose of damaged elm wood. In lower Westchester County, N. Y., it was estimated that approximately 300,000 elms had hanging branches over 3 inches in diameter that required removal.

Security-wage workers employed in winter eradication and elm sanitation numbered from 1,550 to 2,450. The W. P. A. personnel averaged around 2,300 during the last quarter of the year.

SCOURCES OF FUNDS

Operations were carried on during the year under a regular departmental appropriation of $500,000, plus supplementary allotments by the Work Projects Administration of $2,049.085 for field operations and $55,827 for administrative expenses. State appropriations or allotments made available for eradication work by cooperating agencies amounted to $10,000 in Connecticut, $1,875 in Indiana, $500 in Maryland, $5,000 in Massachusetts, $37,755 in New Jersey, $93,268 in New York, and $1,500 in Rhode Island.

WHITE-PINE BLISTER RUST CONTROL

PROGRESS OF RIBES ERADICATION IN 1939

The control of white-pine blister rust in the United States was carried on largely with relief labor. Cooperation was maintained with the Forest Service and Soil Conservation Service of the Department of Agriculture, with the National Park Service and the Office of Indian Affairs of the Department of the Interior, and with States, counties, townships, and individuals.

The combined work of the Bureau and its cooperating agencies during the calendar year 1939 resulted in the eradication of 82,311,851 currant and gooseberry plants (*Ribes*) on white pine control areas totáling 1,863,203 acres. This acreage includes 1,157,112 acres of initial work and 706,091 of rework. The latter acreage is made up of portions of initially worked areas on which control of the rust is

endangered by *Ribes* plants that have developed subsequently from seeds or sprouts. Such areas may require one or two reworkings, and these are timed at periodic intervals so as to remove the *Ribes* before they are able to produce seed. This practice prevents serious damage to the pines, keeps the *Ribes* suppressed, and gradually works toward their permanent elimination from control areas. The details of the *Ribes* eradication work are given in table 6.

TABLE 6.—*Ribes eradication work during the calendar year 1939*

Region	Initial eradication	Reeradication	Total initial eradication and reeradication [1]	Effective labor	*Ribes* destroyed
	Acres	*Acres*	*Acres*	*Man-days*	*Number*
Northeastern States	340,736	359,405	700,141	159,891	13,541,085
Southern Appalachian States	359,132	131,974	491,106	34,218	3,230,851
North Central States	292,613	73,406	366,019	83,292	17,823,644
Western white pine States (Idaho, Montana, Washington)	36,090	68,776	104,866	158,304	28,376,882
Sugar pine States (California and Oregon)	128,541	72,530	201,071	135,119	19,339,389
Rocky Mountain States (Colorado and Wyoming)					
Total	1,157,112	706,091	1,863,203	570,824	82,311,851

[1] Includes work of cooperating Federal, State, and local agencies.

Of the 570,824 man-days of employment provided, 290,637 man-days represent relief labor, 204,202 C. C. C. labor, and 75,985 the labor of cooperating State and local agencies. The number of individuals employed during the season totaled 15,280, of whom 6,589 were obtained from relief rolls, 6,015 from the C. C. C., and 2,676 from the Department and its cooperating State and local agencies.

Of the acreage reported above, 1,313,485 acres were worked by eradication crews paid from allotments of emergency-relief funds to the Bureau and to the Forest Service. The C. C. C. enrollees covered 374,820 acres, and the remaining 174,898 acres were worked by temporary employees of the Department and other cooperating agencies. Numerous States and townships provided appropriations for cooperation in control work on pinelands within their borders, the most substantial of such appropriations being those of New York and Idaho.

Where the work is in remote forest areas, it is necessary to subsist the men in camps. There were 83 such camps operated during the season, of which 45 contained relief laborers and 38 contained temporary employees of the Department and cooperating agencies. In addition, C. C. C. labor was assigned from 178 camps. The work of the C. C. C. on the National forests was performed by enrollees from camps assigned to the Forest Service of this Department. The work on the national parks and Indian reservations was carried on by labor from C. C. C. camps allotted to the National Park Service and Office of Indian Affairs of the Department of the Interior. The C. C. C. work on private and State lands was performed in most cases by labor assigned from camps under the direction of State foresters and the Soil Conservation Service.

STATUS OF CONTROL WORK BY REGIONS

The status of control work at the end of 1939 is shown in table 7.

TABLE 7.—*Status of blister rust control work by regions on Dec. 31, 1939*

Region	Control areas initially protected [1]	Control areas reworked subsequent to initial protection	*Ribes* destroyed	Executive labor
	Acres	*Acres*	*Number*	*Man-days*
Northeastern States	10, 482, 698	3, 742, 997	262, 043, 040	2, 482, 360
Southern Appalachian States	5, 216, 228	899, 018	25, 821, 953	229, 666
North Central States	2, 770, 328	267, 051	204, 630, 483	813, 799
Western white pine States (Idaho, Montana, Washington)	1, 826, 694	275, 619	395, 427, 774	1, 721, 050
Sugar pine States (California and Oregon)	780, 251	191, 769	123, 403, 191	550, 796
Rocky Mountain States [2] (Colorado and Wyoming)	36, 619	1, 962	1, 583, 306	13, 896
Total	21, 112, 818	5, 378, 416	1, 012, 909, 747	5, 811, 567

[1] The figures shown are net totals to Dec. 31, 1939, and do not include worked areas that were later removed from control-area status owing to their reversion to nonpine-producing types as a result of fire, cutting, or other causes.

[2] The work in Colorado and Wyoming represents experimental *Ribes* eradication in stands of limber, whitebark, and bristlecone pines on national forests to develop practical control measures for the Rocky Mountain region in advance of the spread of the rust. The acreages shown for these 2 States are not at present considered as part of the commercial white pine areas of the United States. No work was carried on in these States during 1939.

The aggregate acreage of control areas initially protected from rust by the eradication of *Ribes*, as shown in table 7, represents over two-thirds of the acreage needing protection. Progress in *Ribes* eradication differed in the various white pine regions owing to differences in the time of rust invasion, in the period during which control activities have been under way, in the abundance of *Ribes*, and in the difficulties of working conditions. In recent years the availability of emergency-relief funds has provided a much larger amount of needed labor and has made possible more rapid coverage of control areas in all regions.

SPREAD OF BLISTER RUST IN 1939

During 1939 there was no large extension of the limits of the known infected area in this country. Spread of the rust within the infected parts of the different regions varied considerably, being very slight in the sugar pine region and quite general in the North Central region. Such variations result largely from the influence of prevailing weather conditions on rust development and spread and are normally to be expected.

In the Appalachian region south of Pennsylvania, blister rust was found for the first time on *Ribes* in Kent County, Del., Calvert and Prince Georges Counties, Md.; Albemarle County, Va.; and Preston County, W. Va. On white pine it was found for the first time in Greene County, Va., and in Hardy, Tucker, and Pocahontas Counties, W. Va. This represents an extension of the disease to the southward on *Ribes* of one county in Delaware and two counties in Maryland. Within a few of the previously known infected counties in the southern Appalachian region there was general infection on *Ribes* and some increase of the disease on white pine.

In the North Central region there was considerable spread of the rust. It was found on *Ribes* for the first time in 13 counties in Ohio, 9 in Iowa, 1 in Michigan, 2 in Wisconsin, and 2 in Minnesota. In 67 percent of these counties the rust was found on the cultivated black currant (*Ribes nigrum*), indicating the importance of this species in the distribution of the disease. Blister rust on white pine was found in 2 new counties in Ohio, 2 in Michigan, 2 in Minnesota, and 1 in Wisconsin. In Wisconsin the rust has now been found in every county in the State on either pine or *Ribes*, or on both host plants. In Ohio the disease spread as far south as Champaign County, where it was found on *Ribes*. This is an extension of about 50 miles over its previously known distribution and may be the result of long-distance spread of aeciospores from the north and east. In Iowa most of the spread occurred in the northeast quarter of the State, although O'Brien and Dickinson Counties, in the northwestern part, were reported infected. All the findings in Iowa were on *R. nigrum*. It appears likely that most of the spread in Iowa came from pine infection centers in southern Minnesota.

In the Northeastern States the rust is generally prevalent on both host plants and in nonprotected areas it continues to spread unchecked from *Ribes* to pines. Observations on the spread of the disease in protected areas show that effective control has been accomplished and that new pine infections in such areas are relatively few or absent. The rust is so widely distributed over the Northeastern States that the region is considered generally infected.

In the western white pine region of eastern Washington, northern Idaho, and western Montana no extension of the disease was reported over that known at the end of the calendar year 1938. Additional infection on *Ribes* was observed this year in Glacier National Park, and the disease continues to spread rapidly and destructively in many of the young western white pine stands of northern Idaho that have not been reached in *Ribes* eradication work. There are still nearly 800,000 acres of unprotected white pine on quality sites in this region.

In the sugar pine region the extended hot and dry weather and the lack of favorable winds during the period of canker sporulation appear to have checked the spread of the rust except in the immediate vicinity of pine-infection centers, and even here infection on *Ribes* bushes was relatively light, considering their high susceptibility and the volume of aeciospores produced. This is not unusual, as years in which conditions were unfavorable for rust spread have occurred in the past in other parts of the country.

An examination of the pine-infection area along the east fork of Indian Creek on the Klamath National Forest in California showed that a high proportion of scattered sugar pine seedlings and saplings were diseased. Also, trees located close to *Ribes sanguineum* bushes scattered through the timber on the hillsides were severely infected, and hundreds of cankers had produced spores this year in contrast to a few in any previous year.

The results of scouting in California during the season were negative with respect to the discovery of new locations of infection on *Ribes*, and there was not only no southward extension of the rust on *Ribes* beyond that previously reported, but no infection was found

in 1939 at many locations where it was present on *Ribes* in 1938. One sugar pine was discovered along Girder Creek on the Klamath National Forest with four incipient cankers of 1937 origin. This infection increases to three the number of places where pines have been found infected in California and extends the known range of pine infection in the State to some 14 miles south of the Oregon border. As the disease incubates about 3 years on white pine before it produces aeciospores, any infections on white pines that may have taken place in the last 3 years were still in the developmental stage and some of them probably will begin producing aeciospores for the first time next spring.

PROTECTION OF WHITE PINE NURSERY STOCK

The zones for blister rust control around 93 nurseries containing over 87,000,000 white pines were examined for *Ribes* during 1939. This resulted in the destruction of 85,915 *Ribes* on 40,393 acres, or an average of 2.1 bushes per acre. This represents a very low *Ribes* population in the protective zones around these nurseries and indicates that the trees are well protected from rust infection.

The protection of white pine nursery stock assures the production of trees for forest-planting purposes that are free from blister rust infection. This phase of the control work is a service of value to both grower and consumer, as it provides for the distribution and planting of rust-free trees. As white pines are used extensively for reforestation in this country, a source of planting stock free from blister rust is of considerable importance to forestry and the nursery trade.

ERADICATION OF THE CULTIVATED BLACK CURRANT

Work on the eradication of the cultivated black currant in white pine regions was continued. Most of this work was done in the North Central States. In the other pine regions the removal of this currant has been practically completed, although a few plants may be found annually for several years. The cultivated black currant is an introduced plant, highly susceptible to blister rust, and an active agent in the local and long-distance spread of the disease. Its eradication in white pine regions is a necessary step in establishing control of the disease. During 1939 this work resulted in the removal of 11,352 *Ribes nigrum* plants from 2,154 locations.

MAPPING OF WHITE PINE STANDS FOR PROTECTION FROM BLISTER RUST

White pine stands and their protective borders aggregating 2,711,745 acres were mapped in 1939 for protection from blister rust. This work provided 56,196 man-days of employment. The maps are used in connection with *Ribes* eradication work to show the location of pines worth protection, the boundaries of the protective zones, the character of the ground cover, and the approximate distribution and abundance of *Ribes*. With this information the supervisors of the *Ribes*-eradication crews can quickly locate work areas, determine the eradicative methods to be used, and distribute their labor to the best advantage in carrying out field operations. With the exception of new planting

areas and some stands on national parks, most of the mapping has been completed in the western white pine and sugar pine regions. Considerable work still remains to be done in the eastern white pine regions. Most of the mapping is done during the fall and winter months when *Ribes* eradication is not practicable owing to defoliation of the bushes.

DEVELOPMENTS IN METHODS OF RIBES ERADICATION

Work was continued on the development and improvement of chemical, mechanical, and hand methods for the eradication of *Ribes*.

For the first time an effective chemical treatment was devised for *Ribes triste*. The method involved an early- and a late-season spray and soil drench of Atlacide at the rate of 2.4 pounds per gallon of of water with Tergitol No. 7 as a spreader. Improvements were made in the effectiveness of oil sprays on small plants of *R. roezli* by adding to the Diesel oil about 20 percent by volume of a cheap byproduct, the sulfur dioxide extract obtained from lubricating oil.

The scope of mechanical-power methods was extended to the eradication of heavy patches of *Ribes roezli* in upland sites by the use of special attachments devised for a 25-horsepower Diesel caterpillar tractor. A modified blister rust brush rake was fitted to the front end of the tractor, and a single drum logging winch (sometimes called a hoister drum) was mounted on the rear. The logging winch spooled several hundred feet of steel cable and operated one or more special *Ribes* hooks light enough to be readily handled by one man. This power method was 25 to 50 percent or more cheaper than hand methods in heavy *Ribes* patches. Horse-drawn *Ribes* plows or hooks were further tested and were shown to be specially well adapted to work on open-grown medium-sized bushes of *R. cereum* and *R. roezli*.

Tests of dynamite and of regular grubbing methods on paired *Ribes* bushes showed that substantial savings could be made by the use of dynamite on *R. cereum* bushes having 3,000 or more feet of live stem. Dynamite methods were worked out to provide data on the weight and the number of charges of 20 percent dynamite needed to uproot bushes of various sizes under different soil conditions.

Regular hand tools were improved through the design of a true claw-hammer type of mattock blade which permits the *Ribes* crown to be firmly grasped and then uprooted by a prying technique. Several thousand of these new tools were made by relief labor and were used in regular crew work.

A method in which *Ribes* bushes were marked in advance with white mechanic's waste and the marked bushes then destroyed by a crew was compared with the established crew method. Statistical analysis of field data showed that there was no significant difference between the two methods in the total time needed to accomplish initial eradication, and that the efficiency of the tagging method as shown by data on mop-up time and the number of *Ribes* missed was less than that of the regular method.

Ecological studies were continued in the sugar pine and western white pine regions, and progress was made in compiling data on the regeneration of *Ribes* in relation to fire, logging methods, stand-improvement work, slash disposal, grazing, and the various methods of

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Ribes eradication now being used on a large scale. Methods of pine management that will result in the natural suppression of *Ribes* in the forest are under investigation by the Forest Service, and the Bureau of Entomology and Plant Quarantine cooperates so far as facilities permit.

CEREAL AND FORAGE INSECT INVESTIGATIONS

GRASSHOPPERS

The migration by flight of great swarms of the lesser migratory grasshopper were observed in detail for the first time during the summer of 1939. This migration originated in an area of about 18,000 square miles in eastern Montana, where the infestation averaged about 50 grasshoppers to the square yard. Practically all of them flew out of this area between June 20 and July 15, mostly in the direction of the prevailing wind, toward the northwest. The progress of these swarms was charted and their final termini located. Many swarms continued across the border into Alberta and Saskatchewan. Those that alighted in the United States infested an area bounded by Blaine, Fergus, Judith Basin, Cascade, Teton, Pondera, and Toole Counties in north-central Montana. Egg laying began in that area about August 1 and continued until about September 15.

As one of the results of extensive baiting experiments it was found that sodium fluosilicate as a substitute for the sodium arsenite poison generally used in the bait gave excellent results in concentrations of 3 to 100 pounds of bran or other carrier. Sodium fluosilicate bait kills grasshoppers more rapidly than do arsenical baits and yet is decidedly less dangerous to domestic animals. It would therefore be preferable to arsenical baits if it could be obtained readily in sufficient quantity at as low a cost. Field tests to determine the utility of baiting under fall conditions gave good results so far as kill was concerned. To be effective, however, such baiting must be done before egg laying begins. Experiments to determine the effectiveness of oil- and water-mixed baits distributed by airplane indicated the feasibility of this method and that baits mixed with bran and oil rather than bran and water might work best in airplane distribution. The airplane baiting experiments also indicated the practicability of using drier, lighter baits more suitable for economical and rapid spreading by plane, in quantities as low as 5 pounds per acre, under some conditions.

MORMON CRICKET

Observations on feeding habits showed that the nymphs of the Mormon cricket fed most readily at air temperatures between 76° and 80° F., but that they fed at slightly lower temperatures than did the adults. It also appeared that whenever the temperature was high enough for activity and migration, they would feed on poisoned bait. The speed of migration of nymphs was observed to be about 100 yards in 50 minutes, or a mile a day.

A parasite generically new to science, belonging to the hymenopterous family Encyrtidae, was reared from eggs collected in the Big Horn Mountains of Wyoming. Some 18 individuals emerged from a single cricket egg. The degree of parasitization of Mormon cricket eggs by all parasites, however, averaged only 2.68 percent.

Further extensive trials of the poisoned bait made of bran, sodium fluosilicate, and water on several thousand acres of infested land continued to give excellent results, with kills averaging over 90 percent of the crickets. These tests included the use of a bait in which a small amount of lubricating oil was substituted for the water, the bait being applied by plane on about 3,000 acres of infested land in Nevada, with better than 90 percent kill.

WHITE-FRINGED BEETLE

In field cages all forms of cryolite tested against the white-fringed beetle gave better than 90 percent kill of the adult beetles, but on cotton, calcium arsenate gave better control than cryolite. Several kinds of cryolite dusted on peanut and field-pea foliage caused no injury to those plants. As a result of plot tests of dusting for control of the adults, the population of the next generation of grubs in the soil was lowered. In an experiment on peanuts the fall population of grubs in the undusted plots was 77.4 per square yard as compared with only 22.9 per square yard in the dusted plots.

In tests of several fumigants to kill the grubs in the soil, carbon disulfide was the most efficient where complete mortality, regardless of plant injury, was the objective. In June, with soil temperatures in excess of 76° F., a dosage of 11 milliliters per square foot gave 100 percent kill to a depth of 16 inches.

Trials of lead arsenate as a soil insecticide gave encouraging results in pot tests, even with applications as light as 250 pounds per acre, but in field tests it was less effective and reduced the yield of peanuts 22 percent.

As an ovicide, coal-tar creosote in a 30-percent emulsion was 100 percent effective.

In cultural-control experiments it was demonstrated that a fallow conducted during the period of adult activity, from May to November, was quite as effective in reducing the grub population as a full year's fallow. Results also indicated that the population rapidly diminished in abandoned farm land but that a 2-year period of complete fallow failed to eradicate the insect.

In crop-rotation studies higher larval populations were produced in peanuts and in corn intercropped with velvetbeans than in pure cultures of corn or cotton. Such crops as winter oats, producing an abundance of fibrous roots, were not seriously injured in the presence of heavy grub populations. Tobacco and sugarcane planted in grub-infested soil suffered severe damage.

INSECTS ATTACKING CORN

In experiments with contact insecticides for use on corn in emergency control of chinch bugs, rather satisfactory kills without injury to the corn were obtained with oil emulsions containing either derris extracts or nicotine sulfate. These sprays are promising, at least for use on restricted plantings of high-value pedigreed corn grown for seed.

Further improvements were made in the use of mineral oil for the control of the corn earworm in sweet corn by the addition of small percentages of pyrethrum extract or dichloroethyl ether.

Extensive tests, in several localities, of inbred and hybrid field and sweet corns for resistance to the corn earworm showed wide differences in the degree of infestation. In some of these tests a method of artificial infestation was used to insure significant results. This work gives some promise that reduction of injury by the earworm may be accomplished through the eventual commercial use of resistant strains of corn.

It was discovered that the corn flea beetle, the principal vector of Stewart's disease of corn, may become a carrier of this disease through early spring feeding on wild grasses in which the disease has apparently survived the winter without showing external symptoms. The beetles may thus become infective to young corn on which they subsequently feed, even though they have not carried the bacteria causing the disease inside their bodies through the winter. During the year the larvae of this flea beetle were found to feed on barnyard grass, fall panicum, yellow bristle grass, and a sedge, in addition to other hosts previously determined.

The European corn borer became more abundant in Indiana, whereas marked decreases were observed in Connecticut and New Jersey. Borer populations in general averaged less than 100 per 100 corn plants in the areas surveyed, but in spite of lower populations in the Eastern States they averaged over 500 borers per 100 plants in some parts of Massachusetts, Connecticut, and Rhode Island. Some fields in New Jersey contained concentrations up to 40 borers per plant. During 1939 the pest was found for the first time in extreme northeastern North Carolina and extreme northeastern Illinois.

In an investigation of the nutritional requirements of the European corn borer, feeding tests with corn-leaf and internode tissue indicated that survival and weights of corn-borer larvae are affected by differences in the percentages of moisture, sucrose, reducing sugars, and protein contents in their food; but chemical differences of this kind between resistant and susceptible corns appeared to be insufficient to account for the borer's behavior while feeding on them. Differences observed in average weights of larvae nourished on tissues of resistant strain R4×Hy and the susceptible strain A×Tr, when both were manipulated to produce high sugar concentrations in them, indicated that factors possibly of a physical character in the tissues of R4×Hy interfered with larval feeding, or possibly that defective digestion or assimilation was caused by such characters of the corn tissues. The pH readings of the blood of the larvae varied with those of its host plants.

The isolation and breeding of pedigreed lines of the European corn borer definitely indicated that those having a single generation a year are genetically distinct from those having two or more generations. Studies of field-collected material, however, showed that the multiple-generation strain now occurs quite generally in the Lake States as well as in the Eastern States. Therefore, since there no longer appears to be any object in maintaining quarantines against it in this area, even though it is a distinct strain, the study has been concluded.

In 5 years of study, 1935 to 1939, inclusive, of sweet corn resistant to borer attack near Toledo, Ohio, 690 entries, comprising 451 Bantam, 134 Country Gentleman, and 105 Evergreen lines were tested in threefold replication by the random-block method. Among strains carried

for 3 years as possibly showing inherent resistance, the Bantam selections made the most favorable showing. Further breeding experiments are necessary before tentative conclusions can be drawn. Acceptable evidence of inherent resistance was available, however, for Bantam strain Michigan 1828, Iowa 9, Iowa 45, Minnesota 26–34, Minn. 13–34, Purdue 14, and Michigan 1923. Several strains of Evergreen also gave satisfactory evidence of such resistance.

In general the tests for 1939 of resistance in field corn substantiated the results of previous years. Such lines as R4, L317B2, Mich. 77, and Mich. 106 continued to exhibit material resistance. A strain, I205, formerly considered resistant, failed in 1939 to maintain this quality. Six additional inbreds, viz, Kan. G30, Kan. G26, Ia. R. D. 817, Mich. 285, Ohio 3113–N–1–1–1–2–1, and Ia. Ldg., exhibited resistance, both in 1938 and in 1939.

In some successful spray formulas for corn borer control in early-market sweet corn, an important ingredient was Chinese gallotannin, but owing to its high price and the increasing difficulty of obtaining it, efforts were made in 1939 to find a suitable substitute. This apparently has been discovered in myrobalans tannin extracted from the dried fruit of plants of the genus *Terminalia* originating in India. Its performance indicates that with certain adjustments it promises improvement on Chinese gallotannin. Quabracho extract, another tannin, showed high effectiveness, although its extreme solubility renders it of doubtful utility during wet weather. Cryolite was again found effective as a borer insecticide on sweet corn, but attempts to eliminate its burning effect on the plants were not successful.

During 1939 a total of 81,452 adult parasites of the European corn borer were utilized in the colonization program. In handling these the shipping mortality was less than 1 percent of the whole number. In this work the four species *Chelonus annulipes* Wesm., *Macrocentrus gifuensis* Ashm., *Lydella grisescens* R. D., and *Phaeogenes nigridens* Wesm. were released.

Emphasis was placed especially on the distribution of the egg-larval parasite *Chelonus annulipes* in the Connecticut River Valley and the lower Hudson River Valley. A total of 47,724 adults of that species were liberated in Connecticut, 22,826 in New York State, and 4,476 in Indiana. Colonies of the polyembryonic *Macrocentrus gifuensis* were liberated in the heavily infested areas of Ulster County, N. Y., and Atlantic and Burlington Counties, N. J.

INSECTS ATTACKING SMALL GRAINS

In a continuation of the work of breeding wheats resistant to attack by the hessian fly, a 3-acre field test in California of a resistant hybrid carrying the fly-resistant characteristics of Dawson wheat and designated as "Big Club 38" showed complete freedom from fly infestation as compared with 70-percent infestation in the check plots of ordinary Big Club wheat. In the breeding of fly- and disease-resistant Soft Red Winter wheats, progress was excellent and the results corroborated those obtained in 1938, which indicated that a number of hybrids based on two highly fly-resistant varieties of spring wheat possessed distinct resistance to the fly. In similar work with the Hard Red Winter wheats in Kansas as many as 50 percent of the lightly infested F_4 selections showed entire absence of infestation in the fall. The infesta-

tion in these the following spring was consistently low and indicated that much excellent working material had resulted which possessed resistance to both the hessian fly and disease.

The pale western cutworm, which inhabits the Great Plains grain-growing areas, leads an almost exclusively subterranean existence. It cannot be controlled by the usual means of poisoned bait and its attacks must be met entirely by cultural methods. Field observations showed that grains sown on ground kept in clean fallow during the previous growing season consistently escaped major infestation by this cutworm. It was also shown that deep furrows plowed across the path of advance of the cutworms were of some value as a preventive measure where the worms were entering uninfested small grain from infested stubble fields. In pasture-land studies it was shown that the presence of certain species of grasses was favorable to the multiplication of cutworms, but that other grasses apparently had a repressive influence.

Sporadic outbreaks of both the armyworm and the fall armyworm were rather general in the summer of 1939, and scattered outbreaks of the latter occurred from the Gulf of Mexico to New York.

INSECTS ATTACKING STORED GRAINS

The institution of the ever-normal granary and the consequent general increase in the quantities of grain stored on the farm have called for a determination of the most practical method of protecting such grain from attack by insect pests.

After many experimental fumigations of grain contained in all types of bins commonly found on farms, it was determined that a dosage of 3 gallons of carbon disulfide to 1,000 bushels of grain gave satisfactory control except when the temperature of the grain was too high and a strong wind prevailed. Under these latter conditions excessive evaporation caused such a loss of fumigant that a defective kill resulted. Some danger of fire and explosion accompanies the use of carbon disulfide on farm premises, but a safe fumigant in these respects was found in the commercially available mixture of ethylene dichloride (75 parts) and carbon tetrachloride (25 parts). This was somewhat more costly, however, as twice as great a dosage, or 6 gallons per 1,000 bushels of grain, was required.

It was determined that bagged wheat, stacked in large piles in tightly constructed warehouses, could be successfully fumigated with methyl bromide, 1 pound to 1,000 cubic feet of space.

Wheat and other small grains are known to have some infestation when harvested. A survey of wheat in farm storage in Kansas indicated that more than 90 percent of farm bins of wheat were infested in eastern Kansas and that conditions in Oklahoma and Missouri were still worse. In Illinois south of Champaign cribbed corn was heavily infested with the Angoumois grain moth, so that by September 100 percent of the ears and from 30 to 50 percent of the kernels were infested.

The use of heat for control of insects attacking stored grain is a simple and practical method of protection. An apparatus was designed to heat the grain while it flowed through a revolving cylinder. Temperatures of 210° to 212° F. for from 10 to 40 seconds killed all

insects except the cadelle (an important pest) without injury to the grain.

The question of the extent to which grain in transit becomes infested by contact with infested cars is becoming increasingly important. A study of grain freight cars arriving at railway yards for cleaning revealed that about 57 percent of such cars contained insects prior to the peak of the shipping season. This infestation rose to 91 percent after the peak shipping season had passed. Clean flour placed in wooden box cars that had been treated in various ways to eradicate insects was quickly invaded by insects in large numbers, proving that fumigation of such cars was not effective. Lining these cars with paper previous to loading retarded infestation but failed to prevent it.

Claims have been made by commercial concerns that certain dustlike substances added to stored grain were effective in protecting it from attack by insects. Tests were made of the insecticidal value of finely divided dustlike substances such as lime, sulfur, wood ashes, soybean flour, and prophyllite, when mixed with wheat in the proportions of 1 and 2 pounds per bushel. These all failed to prevent insects from breeding in it at a dangerous rate and proved ineffective and impractical.

A study of the comparative action on the germination of corn of four common fumigants showed that with dosages fatal to insects, and exposures for periods of 72 hours at a temperature of 95° F., hydrocyanic acid, carbon disulfide, and ethylene dichloride did not adversely affect the germination of corn having a moisture content of from 10 to 16 percent. When treated with chloropicrin at a rate of 3 pounds to 1,000 bushels, corn having a moisture content of from 12 to 16 percent showed some injury after an exposure of 12 hours.

That insects cause serious loss to the rice crop in storage was shown by studies recently conducted. In four varieties of rough rice stored for 1 year the loss from insect attack was 12.9 percent. The loss from this source in clean rice was 69½ cents per barrel, and its moisture content influenced the degree to which it was injured. A moisture content below 10 percent was insufficient to sustain insect life, but practically all stored rice contains more moisture than this—in fact, a moisture content of about 14 percent is desired for good milling condition.

In the search for an efficient fumigant for clean rice, it was found that methyl bromide proved satisfactory at atmospheric pressure. When clean-sacked brewers' rice was fumigated with this chemical at 70° F., a dosage of 1½ ounces per 1,000 pounds of rice gave a complete kill after 4 hours' exposure. A dosage of one-half ounce per 1,000 pounds was effective after an exposure of 12 hours. In a subsequent mass fumigation of 3½ million pounds of rice contained in burlap bags stored in a tight concrete warehouse of 365,000 cubic feet capacity, a dosage of 0.85 ounce of methyl bromide per 1,000 pounds of rice killed all insects after an exposure of 42 hours. Fans were used to distribute the gas during fumigation.

INSECTS ATTACKING FORAGE CROPS

Completion of the studies on survival of alfalfa weevil adults in baled hay and straw showed that they can survive in the bales for

more than 7 months after baling. Experimental fumigation of baled alfalfa hay with methyl bromide, partially in cooperation with Oregon State workers, established the fact that a complete kill could be obtained with a dosage of 1 pound per 1,000 cubic feet of space in a gastight chamber at temperatures of 50° F. or higher.

A complete year's observations on the weevil *Hypera brunneipennis* (Boh.), first discovered last year infesting legumes at Yuma, Ariz., indicate that it has only one generation a year and that apparently it prefers clovers of the genus *Melilotus* to alfalfa as a food plant. The adults remained hidden and inactive throughout the summer, emerged gradually, mated late in November and in December, and laid eggs mainly in small dead stems of litter on the soil surface or in young green stems of sourclover during January, February, and March. The larvae of the new brood were mostly full-grown by early spring and had practically all changed to the adult stage by the end of April. Larval mortality was high, and fewer adults appeared in the spring of 1940 than in 1939. Most of these had gone into hiding for the summer by mid-May. Several species of parasites were reared, but the percentage of parasitization was low.

The breeding of alfalfa resistant to the pea aphid was continued in 1939 with lines derived from the work of 1938. The F_4 seedlings tested were the progeny of 56 selfed F_3 plants representing 10 aphid-resistant families. Of the more than 1,000 F_4 plants tested from these families only 2 showed an infestation of aphids. These tests indicated that 8 of the resistant families tested retained complete resistance and are probably homozygously resistant to the pea aphid. In field tests of resistant and susceptible plants the resistant plants remained remarkably free of aphids. Their maximum plant infestation never exceeded 22 percent, whereas susceptible plants were 100 percent infested. In similar breeding operations at Manhattan, Kans., mass testing of alfalfa seedlings revealed individual plants upon which aphids declined to feed. Testing of such plants in cages confirmed this observation. As climatic conditions were unfavorable for open-field testing, cage testing was successfully used. Selections were made from resistant plants for further experiments in 1940.

A large-scale experiment for the control of *Lygus* spp. attacking the alfalfa seed crop in the field was conducted in the Mohawk Valley of Arizona in cooperation with the Arizona Extension Service. The procedure consisted of late winter clean-up of all growing alfalfa and cutting the first hay crop and starting the seed crop at approximately the same time in all fields. This experiment resulted in greatly decreased numbers of *Lygus* and subsequent low percentages of injured seed. Although this represents only one season's trial, there is reason to believe that where community action is fully obtainable this system of control may prove substantially successful.

With the discovery in 1938 of the vetch bruchid in the vetch seed-producing and shipping areas of western Oregon and Washington as well as in the Atlantic States, the need of additional information on effective fumigants for treatment of infested seed became more urgent. Satisfactory dosages of methyl bromide and chloropicrin for use in gastight chambers were therefore worked out and pub-

lished. Two parasites of the vetch bruchid were imported and liberated in infested fields. One of these has since been recovered from field-collected host material, apparently indicating that it has become established.

INSECTS ATTACKING SUGARCANE

According to surveys conducted in 1939, the loss to the sugarcane crop caused by the sugarcane borer was the heaviest for many years and was estimated at $4,231,000. A practical trial was made of control through the application of cryolite dust which gave experimental control on a small scale in 1938. In this recent experiment 40 acres of cane were dusted four times, and the results of these applications were shown to have saved cane to the net value of over $11 per acre from attacks of the borer.

Definite proof was obtained of the presence of distinct resistance to attacks of the borer in certain varieties and strains of sugarcane.

Replicated experiments showed that the selection of noninfested seed cane for planting gave returns of 2 more tons of cane per acre than when heavily infested cane was used as seed. Cane having 7 joints bored was found to give 25 pounds less sugar per ton than sound cane.

WHITE-FRINGED BEETLE CONTROL AND ERADICATION

Among the important accomplishments of the white-fringed beetle program were the apparent eradication of the pest in several limited areas and the drastic reduction of the adult beetle population in all infested areas. This reduction in beetle population materially lessened the danger of natural spread as well as of movement of the pest on host materials. As a direct result of such effective control the regulations of the Federal quarantine were modified to remove restrictions on certain classes of articles from a major portion of the regulated area and to make restrictions less drastic on other host materials.

The methods employed to control the white-fringed beetle consisted of dusting calcium arsenate and cryolite on host plants; of using an oil-base emulsion to eliminate host vegetation along railroad rights-of-way, roadsides, abandoned fields, and waste areas; of adopting clean-cultivation practices in crop areas; of utilizing soil fumigants in certain isolated areas of infestation; and of putting sanitation practices into effect on and in the proximity of places from which materials likely to carry adult beetles were to be consigned for movement to points outside infested areas. Effective applications of insecticidal dusts in nonresidential areas were accomplished by use of Federal-owned airplanes. One or a combination of such control measures was applied on all known infested properties.

As a result of intensive surveys to determine the distribution of the pest, several new points of infestation, all in the approximate vicinity of previously known infestations, were found, the most extensive of which was in the vicinity of Hattiesburg, Miss. The total known infested areas comprise approximately 70,000 acres, located in 6 counties in Alabama, in 3 in Florida, in 8 in Mississippi, and in 4 parishes in Louisiana.

During the year Federal-State-sponsored W. P. A. projects were in operation. The removal of brush and debris and other types of

land-clearing operations facilitated materially the application of control measures and increased their effectiveness.

Full cooperation was given by the affected States in the program. Intrastate quarantines were enacted and enforced.

MORMON CRICKET CONTROL

Mormon cricket control was carried on in cooperation with the States of Colorado, Idaho, Montana, Nebraska, Nevada, Oregon, South Dakota, Washington, and Wyoming, with funds allotted to the Bureau from appropriations granted for the control of emergency outbreaks of insect pests and plant diseases. Other Federal agencies cooperating in the program included the Indian Service and other branches of the Department of the Interior, the Soil Conservation Service, the Civilian Conservation Corps, and the Forest Service. The plan of operation and the division of activities of the respective Federal and State agencies as worked out in advance of the field season were similar to those of the previous year.

Mormon cricket adult and egg surveys conducted in the summer and fall of 1939 indicated that more than 14,000,000 acres were infested, a reduction of about 4,000,000 from the previous season. More than 1,000,000 pounds of sodium arsenite dust were used in protecting crops from invasion by migrating crickets.

The hatching of crickets in 1940 began soon after the middle of March, and control operations were begun on April 7. Approximately 400 laborers were employed at the peak of operations in June. Sodium fluosilicate bait was used in all infested States and gave satisfactory control even in areas of heavy infestation. This material has been specially valuable in districts where both grasshoppers and crickets are present. At the end of the year nearly 1,200,000 pounds (dry weight) of bait had been spread on more than 100,000 acres, metal barrier had been set up for about 200 miles, and more than 25,000 gallons of oil had been used in oiling streams and irrigation ditches. It is estimated that the operations protected more than 1,000,000 acres of crop lands. Damage occurred on only about 7,000 acres of crops. Some loss to vegetation occurred on 900,000 acres of range land. Serious infestations of Mormon crickets in Montana and Wyoming have been reduced to a status of little economic importance. Here and elsewhere the increased use of power equipment in spreading dust and bait has made possible increased protection at a reduced cost.

GRASSHOPPER CONTROL

Operations for the control of grasshoppers in 24 Western States were continued in cooperation with the States and with the aid of other Federal agencies, including the Indian Service and other branches of the Department of the Interior, the Federal Crop Insurance Corporation, the Civilian Conservation Corps, the Soil Conservation Service, the Forest Service, and the Agricultural Adjustment Administration. Funds allocated to this Bureau from the appropriation for the control of incipient and emergency outbreaks of insect pests and plant diseases were used.

Control operations for the 1939 crop season were concluded during the early part of the year. The infestations during the 1939 season

had been heavy and widespread, especially throughout the Great Plains. However, the effectiveness of the campaign was shown in crop savings estimated by State officials at $128,483,225, or $52 worth of crops for each dollar spent on control. Losses were confined principally to isolated farms and localized areas.

The adult and egg surveys conducted during the late summer and early fall of 1939 for the purpose of estimating the quantities of bait materials needed the following year indicated that the degree and extent of infestations of both the migratory and nonmigratory species would be materially reduced in the region as a whole in 1940. Heavy flights from western North Dakota and eastern Montana resulted in an extremely heavy egg deposition in several counties in north-central Montana. From the Black Hills of South Dakota and bordering areas in Wyoming and Nebraska there were flights of lighter intensity into eastern Colorado and western Kansas. Heavy infestations of the migratory hoppers also developed in northern portions of the Red River Valley of Minnesota and North Dakota. Infestations of other species reached local economic importance in parts of South Dakota, Minnesota, Wisconsin, Nebraska, Iowa, Kansas, and Colorado. In the Southwestern Great Plains, at the close of the 1939 crop season, it was found that populations of the long-winged migratory grasshopper, which had occurred in outbreak proportions in the panhandles of Texas and Oklahoma and adjacent areas of Colorado, New Mexico, and Kansas, had been greatly reduced by the control operations.

Control measures in the 1940 field season were effective. Populations of the long-winged migratory grasshopper of the Southwest have been so reduced that no concentrations of this pest are now known to exist anywhere in the United States. In north-central Montana, where the outbreak of the lesser migratory grasshopper seriously threatened the crops, baiting activity on the part of nearly 100 percent of the farmers combined with Bureau-paid labor and the activity of State and county cooperators was responsible for holding crop losses to a minimum.

In addition to bait-spreading by farmers in all the affected States for the protection of crops, large quantities of bait were distributed by Bureau-paid crews on idle and range lands adjacent to croplands in parts of Montana, North Dakota, South Dakota, and the panhandle areas of Oklahoma and Texas, and adjacent areas of Colorado and New Mexico.

The outstanding accomplishment of the season's campaign was the effective control of infestations of the long-winged migratory grasshopper through the use of light airplanes for survey purposes and of heavy planes for the spreading of bait. Two of the planes had been equipped during the winter with modified types of bait hoppers which effected an even and efficient distribution of the standard grasshopper-bait mixture. The aerial equipment was brought into use in areas inaccessible by means of ground spreaders, where infestations were such as to constitute a menace to crop areas. The use of planes in the application of sodium fluosilicate bait to combat grasshoppers as well as Mormon crickets in areas where both these pests exist gave effective results. Three Bureau-owned planes were equipped with bait hoppers. Five additional planes were hired on a contract basis for limited periods to combat heavy infestations

of migratory grasshoppers in the area centering around Amarillo, Tex.

The hatch was late and prolonged. Heavy precipitation early in the season kept the vegetation green on roadsides and idle land where the hoppers remained feeding. However, after the close of June, hot, dry weather in many areas caused drying of native vegetation, and the grasshopper injury to crops increased rapidly. Late in July local flights were reported in Montana, North Dakota, and western Minnesota. Mass flights of grasshoppers over long distances had not occurred in 1940 up to July.

Field activities relating to grasshopper and Mormon cricket control were combined in December 1939, with headquarters at Denver, Colo.

CHINCH BUG CONTROL

As indicated by the Federal-State survey conducted during the fall of 1939, chinch bugs developed in outbreak numbers during the latter part of the year over a rather extensive area in the southern half of Iowa, the northern third of Missouri, southeastern Nebraska, the eastern third of Kansas, several counties in northeastern Oklahoma, and localized areas in Indiana and Illinois. With an allotment from the appropriation for the control of incipient and emergency outbreaks of insects, nearly 2½ million gallons of creosote were purchased and consigned to 167 counties in these 7 States for distribution to farmers for use in erecting and maintaining barriers for the protection of corn.

Throughout the infested area excellent cooperation on the part of farmers in using creosote supplied by the Federal Government was instrumental in saving valuable corn crops. In a few localized areas lack of farmer participation and adverse weather conditions, which prevented the erection and maintenance of barriers, resulted in economic loss.

EUROPEAN CORN BORER INSPECTION AND CERTIFICATION

Inspection services for European corn borer certification were available during the year through the Japanese beetle and gypsy moth inspection corps and by corn borer inspectors stationed in Indiana and Michigan to fulfill the requirements of State European corn borer quarantines and orders of Arizona, California, Colorado, Georgia, Louisiana, Nevada, Oregon, Texas, and Utah. States in which infestations of the corn borer have been found and throughout which the inspection services are available include the six New England States and New York, New Jersey, Pennsylvania, Delaware, Maryland, Virginia, West Virginia, North Carolina, Kentucky, Ohio, Indiana, Illinois, Michigan, and Wisconsin. Host plants designated in the State quarantines are corn, broomcorn, sorghum, sudan grass, chrysanthemums, asters, zinnias, cosmos, hollyhocks, dahlias, gladiolus, beets with tops, celery, beans, rhubarb, and oat and rye straw.

Certificates issued during the year numbered 36,661, a decrease of 27 percent from the preceding year. A greater proportion of the certificates was issued to cover bulk shipments rather than individual packages, the valuation of the commodities certified being thus increased to $205,0000, an increase of approximately 30 percent. The

principal host plants inspected and certified comprised dahlias, gladiolus, and chrysanthemums, from Maryland, New York, Ohio, Pennsylvania, and Virginia.

BARBERRY ERADICATION

Recent progress in barberry eradication has demonstrated that, (1) in approximately 75 percent of the counties comprising the 17 States engaged in the regional stem rust control program, barberry bushes have escaped from cultivation, and an intensive survey of all timbered areas and other uncultivated lands is necessary to insure complete eradication; (2) by carefully mapping barberry-infested areas when the initial survey is made, it is possible to eliminate from further attention large areas where bushes have not become established, or in which eradication has been accomplished, thus reducing by approximately 50 percent the territory that will require one or more reinspections; (3) single barberry bushes, if allowed to remain scattered throughout grain-growing areas, not only are sources of seed and local rust-infection centers but may serve as sources of new physiologic races of the disease, some of which may be capable of attacking varieties of small grain that are resistant to the particular races of the disease generally prevalent at the present time.

To protect grain crops from stem rust has been foremost in the minds of farmers in the Central and Western States for nearly 40 years. It was not until 1918, however, that a regional control program involving 13 North Central States was undertaken, with the United States Department of Agriculture assuming responsibility for general administration and coordination of the work. At that time legislation was enacted in Colorado, Illinois, Indiana, Iowa, Michigan, Minnesota, Montana, Nebraska, North Dakota, Ohio, South Dakota, Wisconsin, and Wyoming which prohibited further propagation or sale of rust-susceptible species of barberry, and a Federal quarantine was established to prevent shipment of other than immune species into or between protected States. During the period 1918–32 an extensive educational program was conducted to demonstrate to grain growers and others the extent to which local barberry bushes were responsible for destructive epidemics of stem rust. Statewide surveys were made to determine where, and to what extent, barberry bushes had become established in grain-growing areas. Funds were not available with which to undertake intensive surveys of entire counties, and control work was conducted on an area basis in communities where rust losses had been particularly severe. While progress toward complete eradication was slow during this period, 84,518 properties were cleared of 18,665,000 barberry bushes, many of which were located in, or immediately adjacent to, the more extensive grain-growing areas of the country.

CONTROL OPERATIONS EXPANDED WITH W. P. A. LABOR

Since August 1933 an average of 2,200 security-wage employees have been continuously assigned to the stem rust-control program, and the protected area has been extended to include Missouri, Pennsylvania, Virginia, and West Virginia. W. P. A. laborers working under the direction of Bureau supervisors have completed an intensive survey of more than 294,600 square miles in 17 States and have

destroyed 239,973,170 barberry bushes on 34,440 different properties, bringing the total of bushes destroyed during the entire program to 259,080,480. Of these, 217,776,080 were *Berberis canadensis*, a species native to Virginia and West Virginia but found only in very limited numbers elsewhere in the control area; 9,331,490 were the native form *B. fendleri*, in Colorado; and practically all the others were the common European barberry, *B. vulgaris*.

PROGRESS DURING THE YEAR

State agencies, counties, municipalities, and individuals continued active participation in the eradication program during the year. A number of counties and cities furnished trucks for transportation of laborers and supplies. Farmers cooperated by providing storage space and supplying labor, the use of teams, tractors, and other equipment. Aerial photographs obtained through the cooperation of the Soil Conservation Service aided in the more efficient planning of survey activities. Experienced Bureau personnel closely supervised the work of relief labor crews, with the result that continued improvement was made in both survey and eradication methods. Field supervisors used every available opportunity to demonstrate the spread of stem rust from barberry bushes to grain, to explain the nature and economic importance of the disease and the distinguishing characters of the rust-susceptible barberry, and to recommend methods of eradication. A systematic survey was made to determine the prevalence and severity of stem rust in the different crop sections of each State in the control area, and in Kansas, Oklahoma, Texas, and Mexico.

Table 8 shows, by States, the progress that was made in eradication during the year.

TABLE 8.—*Progress in barberry eradication by States, fiscal year 1940*

State	Counties surveyed	Area surveyed	Properties cleared of bushes	Barberry bushes destroyed	Salt used
	Number	*Square miles*	*Number*	*Number*	*Tons*
Colorado	9	937	111	2,145,084	9.7
Illinois	18	3,390	139	2,179	4.31
Indiana	25	3,601	81	71,888	17.44
Iowa	32	4,037	223	9,585	26.1
Michigan	16	1,542	216	17,402	20.3
Minnesota	19	3,985	228	6,067	26.53
Montana	4	46	15	213	.41
Nebraska	12	16,473	25	82	.38
North Dakota	4	3,654	3	615	.25
Ohio	30	3,803	139	10,255	7.3
South Dakota	8	399	8	51	.33
Wisconsin	24	969	241	20,823	21.16
Wyoming	2	428	1	1	0
Total	293	43,264	1,430	2,284,245	134.21
Missouri	9	1,398	24	331	.16
Pennsylvania	13	1,157	854	1,312,379	435.9
Virginia	17	232	280	9,711,282	524.61
West Virginia	8	353	141	18,022,796	541.23
Total	47	3,140	1,299	29,046,788	1,501.90
Grand total	250	46,404	2,729	31,331,033	1,636.11

Dry salt and salt brine continue to be the most practical and effective chemicals available for eradication purposes. Chlorates were used to some extent in Colorado for cleaning up small areas and scattered bushes of *Berberis fendleri*. Bushes were dug only when it appeared that chemicals might injure nearby trees, shrubs, or other vegetation of value.

During the year State W. P. A. projects were operated under the technical supervision of Bureau personnel in Colorado, Illinois, Minnesota, Pennsylvania, and Virginia to supplement work made possible with funds allotted to Federal agencies from emergency relief sources.

STATUS OF BARBERRY ERADICATION

The status of the barberry-eradication program varies considerably in different States within the control area, and in different areas within individual States. In Montana, North Dakota, South Dakota, Wyoming, western Nebraska, and eastern Colorado the initial survey has been completed, and the work remaining to be done is of a clean-up nature which will involve one or more reinspections of known infested properties, educational work to enlist the aid of property owners in reporting or destroying bushes that may so far have escaped detection, and rust surveys to determine localities where local epidemics of the disease indicate possible sources of inoculum.

In western Colorado, eastern Nebraska, Iowa, Missouri, Minnesota, Wisconsin, Illinois, Indiana, Ohio, and Michigan, where infested areas exist in greater numbers and are far more extensive, many of them involving all uncultivated lands in entire townships or even counties, the status of the program is not so far advanced. The initial eradication has been completed in most of the larger infestations, but in many instances seedlings are known to be developing and must be destroyed before they in turn reach the fruiting stage. In these States, as in those farther west, detailed records including maps have been made of all locations where barberry bushes were found, thus simplifying future clean-up work.

There has been no change in the policy of restricting field operations in Pennsylvania, Virginia, and West Virginia to the more important grain-growing valleys. These States are not subject to the sweeping winds that frequently distribute rust spores for great distances in the Plains area, and wherever bushes are destroyed there is a marked reduction the following year in the amount of rust in the vicinity.

STEM RUST DAMAGE NEGLIGIBLE IN 1939

The development and spread of stem rust was studied in 1939 along the following three major lines: (1) Field observations were made throughout the United States and in Mexico to determine where, and under what conditions, stem rust caused appreciable damage; (2) nearly 2,000 prepared slides (spore traps) were exposed during the period April 1 to June 30 at 23 selected stations in 20 States, and an examination of these slides indicated on what dates, and to what extent, rust spores were widely distributed by air currents; and (3) specimens of rusted grain were collected from rep-

resentative localities within each geographic area of the United States and Mexico and studies made to determine the particular races of the fungus present.

Stem rust caused only slight aggregate damage to any of the small-grain crops in 1939. The red, or summer, stage of the fungus did not survive the winter in Texas as abundantly as in some years. In northern Mexico rust persisted throughout the winter in occasional early-sown fields of wheat; however, there was less rust than usual in the spring in this area. Inoculum of southern origin was not so abundant as in some years, and the spread northward was much later than usual. Crops ripened over wide areas in eastern Kansas and Missouri about June 15, thus preventing further increase of inoculum in this section. In the spring-wheat area there was an increase in acreage of varieties of grain resistant to the more prevalent races of stem rust, and hot dry weather caused premature ripening of crops in many localities.

Numerous local epidemics of stem rust were traceable to barberries. These were particularly noticeable because of the absence of a large amount of infection in grain fields some distance away from bushes.

Examination of slides exposed in representative sections of the United States indicated that urediospores of stem rust were deposited later than usual and that spore showers were comparatively light. No stem rust spores were found on slides exposed during April and the first half of May and only small numbers appeared during the last half of May. The amount of infection reaching the States from Nebraska northward, as indicated by spore counts, compared in quantity with that of 1936 rather than with certain years when rust has become epidemic over wide areas.

The identification of physiologic races of stem rust in 1939 indicated a high degree of similarity in the population of races in northern Mexico and the United States. Most of the races found in northern Mexico in the spring were collected later in the season in the United States. Five races were most prevalent and widespread, constituting over 95 percent of all isolates. These were, in the order of their prevalence, races 56, 38, 17, 19, and 11. Race 56 ranked first in prevalence for the sixth consecutive year; however, it decreased from 66 percent of all isolates in 1938 to 59 percent in 1939. Although widely distributed, it occurred in greatest concentration in the West Central States, including Iowa, Nebraska, South Dakota, North Dakota, and Minnesota. Race 56 was isolated from all samples of Ceres wheat collected in North Dakota.

It is significant that the tritici, or wheat, variety of stem rust was more prevalent this year in barberry collections than either the rye or oat varieties. In addition, aecial material from barberries continued to yield more physiologic races of rust than did the grain collections. A different race of rust was found in approximately every fifth barberry collection, while a different race was found only in every fifty-second collection of rust from wheat.

POPULATION TRENDS IN PARASITIC STRAINS OF THE WHEAT STEM RUST FUNGUS

It is evident from results of the past year and those of previous years that there are decided population shifts in parasitic races of the wheat stem rust fungus, *Puccinia graminis tritici*. A summary

of the results for the decade 1930–39 indicates that the prevalence of some races has fluctuated from year to year, that other races have decreased in prevalence, some of them almost to the vanishing point, that others have shown a general tendency to increase slowly, and that one (race 56) increased slowly for a time and then suddenly increased very rapidly. Race 56 has ranked first in prevalence for 6 successive years, reaching the high of 66 percent in 1938 and dropping to 59 percent in 1939. Race 56 was isolated from 100 percent of the collections of rusted bread wheat obtained from North Dakota. If certain other races were to predominate in future years as 56 now does, the behavior of at least some of these varieties would be entirely different from what it now is.

These studies on population trends, when correlated with the behavior of certain varieties of grain toward rust, indicate clearly the necessity for information of this type in explaining the variable behavior of commercial varieties and in connection with the breeding and testing of varieties for resistance to stem rust. For example, races 36 and 49 were rather prevalent during the first half of the decade but decreased to less than 1 percent in 1939. Similarly, races 11, 21, and 34, which were rather prevalent during some years of the decade, were rather rare in 1938 and 1939. As there is so great a difference in the relative susceptibility of wheat varieties to different races, and since the prevalence of races varies so greatly, it is becoming increasingly evident that everything possible should be done to decrease the number of races.

Experiments during 1939 confirm preliminary evidence and observations that the wheat stem rust fungus comprises an indefinite number of biotypes, many of which differ from each other only slightly.

Further evidence was obtained during 1939 that a great many biotypes may result from segregation and recombination on barberries. For example, a number of virulent races of rust have been obtained as a result of selfing a given race on barberry. Furthermore, isolations from crosses between varieties of stem rust indicate that the number of biotypes that can originate as a result of the sexual process on the bushes is almost incalculable. There is additional evidence that races developed on barberries may become established and be disseminated for considerable distances. Such evidence was obtained as a result of identifying uncommon races in western North Dakota.

Barberries are important, not only in connection with the wheat stem rust but also in connection with stem rust of oats (*Puccinia graminis avenae*) and rye rust (*P. graminis secalis*). This is shown by the fact that, of all the identifications of aecial material from barberry leaves, wheat stem rust constituted 46 percent, rye stem rust 34 percent, and oat stem rust 20 percent, in 1939.

It is now clear that rust which occurs in the southern part of the United States is not ordinarily the result of spores blown northward from southern Mexico. This conclusion is based on physiologic-race surveys and observations. Race 56, which occupied first rank in the United States for the last 6 years, has not been found at all in southern Mexico. Certain sections of northern Mexico, on the other hand, must be considered with the southern part of the United States in the development of rust epidemics.

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SUSCEPTIBILITY TESTS, NURSERY INSPECTION, AND IDENTIFICATION

Tests to determine resistance or susceptibility of the many existing species of barberry to stem rust were continued under greenhouse conditions at the University Farm, St. Paul, Minn. Fifty-six different barberries, including 9 hybrids, were inoculated during the year, comprising 65 series of plantings. Each series consisted of 4 or 5 plants of the species under test, plus 1 plant known to be susceptible. Of the 63 series tested, infection occurred in varying degrees in 58. No new species were added to the susceptible list, as these results merely corroborated those obtained in the outdoor garden at Bell, Md. It is expected, however, that 41 species will be added to the susceptible list and 6 species to the resistant or immune list, after they are checked taxonomically.

During the summer of 1939 requests for inspection were received from 49 nurserymen and 1 seed house. As a result of these requests, together with the cooperation of State leaders in charge of barberry-eradication work in several States, a total of 13,214 barberries were removed from nurseries and private home sites on the nursery grounds. Forty-four nurseries received permits to ship immune species of *Berberis* and *Mahonia* into or between States comprising the eradication area.

More than 125 specimens taken from barberry and mahonia plants were received for identification, and 40 additional specimens were identified and filed. Forty-five packets of barberry seed received from China during the year were stratified and planted. These are all numbered, and will be identified as soon as corresponding herbarium specimens are made available.

TRUCK CROP AND GARDEN INSECT INVESTIGATIONS

In this field of research the more important practical applications of the results obtained were concerned with the control of the tomato fruitworm in southern California and Utah, of the pea weevil in the Northwest, of cabbage caterpillars as they affect cabbage grown in South Carolina, and of the tobacco flea beetle on flue-cured tobacco in North and South Carolina.

A survey of tobacco growers' pack houses for the tobacco moth in North Carolina, South Carolina, Virginia, and Georgia was completed and showed that the insect may develop into an important pest in pack houses in North Carolina and Virginia. Heretofore it has been known only as a pest in stored tobacco.

The work on the sweetpotato weevil yielded additional valuable information on the survival of the insect under variable seasonal conditions, its ability to disperse by flight, and its seasonal habits, which can be used in the prosecution of an eradication program. In this study was included an extensive survey of the wild plants upon which the weevil may survive for limited periods, or thrive and serve as reservoirs of infestation of the cultivated sweetpotatoes.

Wireworms, both in the irrigated lands of the Northwest and in California, continued to be important problems. Early experiments with dichloroethyl ether as a soil fumigant against them showed considerable promise. More recent tests, however, seemed to indicate

that the margin of safety between an effective dosage and plant injury is narrow.

Naphthalene as a soil fumigant was tested as a control for wireworms in tobacco land near Windsor, Conn., and the indications from this and other practical experiments are that the soil types and temperatures at the time it is necessary to treat the land will limit its effective use in the Eastern States.

The establishment of a control program to protect raspberries from infestations of the raspberry fruitworm and blackberries from damage by the red berry mite in the Puyallup Valley of Washington has assured the successful production of raspberries free of the fruitworm, and the protection of blackberry plantings from injury by the red berry mite. The control of the raspberry fruitworm is effected by timely applications of a dust mixture containing 1 percent of rotenone derived either from derris or cube. Proper use of oils and of lime-sulfur sprays will protect the blackberry crop from the red berry mite.

An outstanding feature in the ornamental-plant field was the successful application by growers of gladiolus, both commercial and home gardeners, of the tartar emetic and brown sugar spray formula which has been in the process of development during the last several years. Experimental work this year showed that this spray may be cheapened without reducing its effectiveness by using only 2 pounds of tartar emetic to 100 gallons of water, instead of 4 pounds as has been recommended heretofore.

A spray of derris, pyrethrum, and sulfonated castor oil continues to be the most effective material tested as a treatment for the red spider infesting greenhouse cucumbers. A tartar emetic spray consisting of 2 to 3 gallons of glycerin and 2 to 4 pounds of tartar emetic per 100 gallons of water was also very effective against the red spider. Indications are that tartar emetic sprays may be useful also against the orchid thrips and the flower thrips. The results with methyl bromide as a greenhouse fumigant against the red spider and the Mexican mealybug were variable, and no conclusions as to its actual usefulness can be drawn at this time.

High populations of the beet leafhopper occurred in southern Idaho and the San Joaquin Valley of California. Overwintering forms of the leafhopper were found in April in the Billings, Mont., area at 16 of the 21 locations examined. This confirms the findings of 1936 and 1938 and definitely shows that this insect can survive certain types of winter in the Yellowstone Valley of Montana.

In a study of the insects affecting seed beets in southern Arizona a direction correlation was found between the numbers of *Lygus* spp. present on the seed stalks and the percentage of nonviable seed produced. Cage studies showed that beside the species of *Lygus*, Say's plant bug and another plant bug, *Thyanta custator* (F.), common to the area were capable of reducing the percentage of viable seed and also the weight of the seed per unit volume. The quantity of seed produced was not reduced by these insects nor was the percentage of small seed increased. Aphids did not affect the viability of the seed but apparently reduced the quantity, while the false chinch bug, numbering up to 500 per plant, had little if any effect, either on the plant or on the seed produced.

TOMATO FRUITWORM

Extensive field experiments on the tomato fruitworm were conducted in southern California and Utah in an effort to develop a profitable and commercially satisfactory control.

In Ohio small field-plot experiments were conducted as a means of determining as accurately as possible the differences between the toxicity of calcium arsenate and that of cryolite and other materials against this insect.

In southern California cryolite and calcium arsenate were used in large field-scale experiments. In 5 different commercial plantings where experimental plots were located the insect damage averaged 14.6 percent in the 20 untreated plots. This represented an average loss of 87.6 boxes of tomatoes per acre, or a monetary loss of approximately $43.80. In a comparable series of 20 plots to which was applied an undiluted synthetic cryolite dust the average loss was 3.1 percent. A critical analysis of these results shows the saving from treatments with cryolite to be between 10 and 13 percent of a tomato crop worth on the average $300 per acre. On this basis, when the cost of control operations was deducted, the net return ranged from $20.40 to $28.80 per acre for these treatments. In similar plots treated with undiluted calcium arsenate dust the net return ranged from $11.55 to $19.95 per acre.

Included in this series of experiments were five other cryolite-dust treatments and four cryolite-bait treatments. All the insecticides were applied when the first fruits began to set, and twice after this period at intervals of 2 weeks. The dusts were applied with a rotary hand-type duster at the rate of 10, 20, and 30 pounds per acre, respectively, for the three applications. The baits were scattered by hand over the plants at the rates of 40, 60, and 80 pounds per acre for the three respective treatments. Imported synthetic, domestic synthetic, and natural cryolite containing approximately 96, 83, and 93 percent of sodium fluoaluminate, respectively, were used in these experiments, in both the undiluted and diluted forms. The diluted dusts were prepared with talc and contained 70 percent of the sodium fluoaluminate. Although the control value of the undiluted and the diluted dusts tended to a correlation with the percentage of sodium fluoride contained in the mixture, the differences in control values were of little significance. Baits containing 1 pound of natural cryolite to 10 pounds of corn meal and 1 pound of natural cryolite to 10 pounds of bran were approximately as effective as the cryolite dust. A bait mixture containing sawdust as a carrier was definitely inferior.

In a series of experiments where the cryolite and calcium arsenate dust mixtures were applied with power dusting machinery the differences in the control obtained with the six types of cryolite dusts used were less pronounced than in the series in which hand machines were employed. However, as in the case of the treatments with hand machines the particular brand of calcium arsenate used in both these series was inferior to the cryolite dust. Twelve and two-tenths percent of the fruits in the undusted plots were damaged by the tomato fruitworm as compared with an average of 4½ percent in the plots dusted with cryolite and 7 percent in those dusted with calcium arsenate.

In Utah the tomato fruitworm infestation was of such a nature that no definite conclusions could be drawn from the results obtained.

In Ohio, in the small-scale comparative-toxicity tests, indications are that the particular calcium arsenate used undiluted and a synthetic cryolite-talc mixture containing 70 percent of sodium fluoaluminate had about the same toxicity to the tomato fruitworm. An undiluted domestic cryolite, diluted domestic, imported synthetic, and natural cryolites containing 70 percent of sodium fluoaluminate, and a white corn-meal bait containing 1 part of cryolite to 10 parts of the corn meal gave fair control as compared with 70 percent wormy fruit in the check plots. These plots were artificially infested.

PEA WEEVIL

Investigations on the seasonal habits, hibernation, and control of the pea weevil as a pest of dried peas, peas grown for processing, and Austrian peas were conducted in Idaho, Washington, and Oregon in cooperation with these States. Encouraged by the success the green-pea growers had in control of the weevil with rotenone-bearing dust, a method developed by cooperative work of the State and Federal entomologists, the growers of seed peas attempted for the first time to control the pea weevil in their plantings. Over the Palouse area approximately 100 tons of dust materials were used to treat about 31 percent of the crop. The average infestation on all dusted fields was 5.2 percent as opposed to 11.3 percent in undusted fields.

In the Blue Mountain region, where the peas are grown mostly for processing, the large-scale use of dust materials containing from three-fourths to 1 percent of rotenone resulted for the third consecutive year in satisfactory weevil control. During these 3 years only a small quantity of peas has been eliminated from the cannery pack because of weevil damage. The fact that this control measure is feasible and practical is now well established. However, the number of applications of the dust and their timing vary seasonally and geographically and are dependent on the weevil populations present. The date of the weevil influx to the fields from hibernation and the accompanying meteorological conditions and the actual timing and number of dust applications will have to be determined for each area and each season by competent observers.

Further information has been secured on the amount of damage to peas caused by the dusting machinery. The greatest damage (approximately 4 percent) followed the use of a duster with a 40-foot boom attached to a crawler-type tractor with 8-inch treads. The least damage (approximately 2 percent) was done by a horse-drawn duster—a two-wheeled affair having a 40-foot boom. It was also determined that a light truck driven over the pea fields when these were muddy did more damage than a dual-wheel truck on a dry field.

Records of emergence of the weevils from hibernation quarters showed that in the Walla Walla area the weevils emerged over a period of 117 days, that is, from March 29 to July 23, although the greatest emergence occurred in May and June, 61 percent of the total appearing in the fields in May. In the locations that were cooler because of higher elevations the emergence proceeded much more

slowly and the peak occurred later than in the warmer or lower levels. This explains why the weevils appear in the fields later in the season in the higher areas.

Large-scale field tests involving the dusting of the more heavily infested edges of the field of Austrian winter field peas were continued in 1939. The results as a whole were satisfactory, and the dusting of Austrian winter peas is now generally practiced throughout the area planted to this important seed crop. Results in general indicate that the germination of these peas is governed almost solely by the presence of the weevil grubs; and that if the weevil infestations can be held at less than 10 percent, germination tests satisfactory to the industry can be maintained. This has been accomplished for the peas in two successive seasons in the areas under observation; and while substantial improvements may be made in the present method of reducing pea weevil infestations in Austrian field peas, the present methods may be considered reasonably satisfactory. Even with applications of dusts, however, the importance of early harvest and prompt fumigation of the peas after harvest should not be overlooked, as a delay of 5 to 10 days from the earliest possible harvest date may increase the loss manyfold.

CABBAGE CATERPILLARS

A control experiment against cabbage caterpillars was carried out on the scale of a commercial planting of fall-grown cabbage at Charleston, S. C. Its purpose was to test the practical application of the results obtained in toxicity and control experiments, conducted during previous years, which had for their major objective the determination of a satisfactory control program for caterpillars on cabbage with special reference to the avoidance of a poisonous insecticidal residue on the marketed product. The program in this field experiment consisted essentially of applying cryolite-containing dust mixtures at regular intervals before the cabbage began to form heads, and of rotenone-containing dusts during the heading stage of plant growth. Cryolite was used because it is toxic to the corn earworm and cutworms as well as to the cabbage looper, the diamond-back moth larva, and the imported cabbageworm, whereas rotenone-containing dusts are effective only against the three last-named pests. Cryolite is not recommended for use after the cabbage plants have begun to head because of the danger that poisonous deposits may be left on them at harvesttime.

A total of 10 applications of insecticidal dusts, made with equipment ordinarily used by the grower, were given at approximate intervals of 10 days between August 21 and November 15. This included the period of plant growth from soon after the plants appeared above ground in the field until the weather was sufficiently cool to prevent further insect development and damage. The first seven applications, made before the cabbage began to form heads, consisted of a dust mixture of synthetic cryolite and talc, 1 part to 2 parts, respectively, by weight, put on at a rate of 21 pounds per acre per application. The last three applications, made during the heading stage of plant growth, consisted of a derris-talc dust mixture containing 1 percent of rotenone, put on at a rate of 22 pounds per acre per application. Derris-root powder was added to the cryolite-dust mixture for the

first two applications in an effort to control an infestation of leafhoppers on the young cabbage. The cost of this program amounted to $19.50 per acre.

Harvest records from this planting showed an actual yield of 11.2 tons per acre of U. S. No. 1 grade cabbage, which represented the yield of only 87.5 percent of the plants. The loss of 12.5 percent of the plants, or the equivalent of approximately 3,200 pounds of cabbage, was divided as follows: 3.5 percent, or 896 pounds, from damage by the imported cabbageworm, the cabbage looper, and larvae of the diamondback moth; 2 percent, or 512 pounds, from damage by the corn earworm and cutworms; and 7 percent, or 1,792 pounds, from other kinds of damage, principally from abnormally cold weather.

On the basis of a market value of 1 cent per pound for U. S. No. 1 grade cabbage, this planting suffered an actual loss from insect damage of only 5½ percent, or $14.08 per acre. Careful studies conducted during several years, however, show that growers suffer a loss of 20 percent of their cabbage crops annually from insect damage, despite control measures. An equivalent loss in this experimental commercial planting would have amounted to $51.20 per acre.

The success of this program cannot be ascribed to greater effectiveness of the insecticides used, because studies have shown that those used by the growers are as effective as the ones substituted. Instead, evidence indicates that the superior effectiveness of the control program followed was due, primarily, to thorough application of the insecticides at regular intervals throughout the period when the cabbage was subject to insect attacks. It may be considered, therefore, that an insecticidal program has been developed which, when systematically and thoroughly applied, will give good control of cabbage caterpillars. Moreover, the proper use of this program successfully avoids the presence of poisonous insecticidal deposits on the marketed cabbage.

TOBACCO INSECTS

OUTBREAK OF THE TOBACCO MOTH IN GROWERS' PACK HOUSES

Until the fall of 1938 depredations of the tobacco moth have been confined principally to flue-cured or imported tobacco packed in hogsheads or other containers and stored in warehouses. Discovery of the moth in growers' pack houses in the fall of 1938 and in subsequent surveys, however, shows this pest to be a menace to the producer of flue-cured tobacco in North Carolina and Virginia.

A single infestation of the tobacco moth in a grower's pack house was recorded in 1937. By late summer and the early fall of 1938 it became evident that this insect was to be found in many widely separated areas and was damaging tobacco in many pack houses, particularly those near the storage centers of Durham, Reidsville, and Winston-Salem, N. C., and Danville, Va. While in general the damage observed in the fall of 1938 was fairly light, in the most severely damaged pack houses there was practically a complete loss of the newly harvested and cured crop.

A more intensive survey for moth-infested pack houses was made during the period August 1 to December 15, 1939, and in this survey one or more inspections were made in 371 widely separated pack

houses. From information thus obtained it was concluded that there were no infestations of the tobacco moth in pack houses of either the Georgia or South Carolina belts. Except for the heavily infested Farmville area in the eastern Carolina belt of North Carolina, infestation and damage, while generally light, were found in about one-third of the pack houses examined. Infestation and damage ranging from light to severe were found in slightly more than one-half of the pack houses examined in the old belt of North Carolina and Virginia. Serious losses were not common except in limited areas of concentrated infestation.

Not only were the infested areas of 1938 increased in extent in 1939 but other infested areas were discovered. A study of these strongly indicated that the original sources of infestation for the pack houses were the large storage warehouses. Some of the newer and lighter infestations in pack houses appeared to have resulted from moths coming directly from storage warehouses. Others were traced to the movement of infested scrap tobacco from the auction-market warehouse floors to pack houses, where it was stored until the following spring to be used on the soil as fertilizer. The information obtained indicated that infestations of the moth can survive from one year to the next in the ordinary pack houses, and that the surviving moths may spread to other nearby pack houses.

On the basis of the information obtained from the survey it is believed that the most important original sources of infestation were the tobacco storage warehouses at Farmville, Durham, Reidsville, and Winston-Salem, N. C., and possibly Danville, Va. The natural spread of infestation in pack houses seems to have been in a general northeasterly direction from the storage centers.

In the more heavily, widespread infested areas the moth appears to be well established on the farms and to carry over from season to season. While no indication can be given as to the probable extent and importance that this insect menace may attain, observations showed that one means by which it can readily be spread is by the transportation of infested tobacco to a market in an uninfested area. In this manner there is danger of the infestation becoming established in the South Carolina belt, because of the common practice of selling tobacco there from areas now known to be infested with the tobacco moth. Other observations made during the survey indicate that a promising means of relieving the situation is that of careful packhouse sanitation. This would appear especially hopeful where nearby storage warehouses have been screened and thoroughly cleaned up so as to remove a source of reinfestation.

TOBACCO MOTH AND CIGARETTE BEETLE IN TRANSPORTATION

Inspection of ships' holds at Norfolk and Newport News, Va., during October, November, and December 1939, showed that practically all the imported tobacco examined was infested with both the tobacco moth and the cigarette beetle, the infestation in most instances being heavy. In some cases two or three types of imported tobacco were placed in the same hold, thus introducing the possibility of subjecting uninfested types to infestation during transit. In other cases American tobacco for export was loaded in ships' holds from

which heavily infested imported tobacco had just been removed. In such instances, even though American tobacco has been fumigated prior to export, it is subject to infestation during transit.

Inspections of railroad cars indicate that many moths are transported to the storage warehouses and ports along with the tobacco. Moths carried in this manner are capable of starting new infestations in tobaccos that have recently been fumigated, as well as in recently cured tobacco, en route to storage warehouses or ports.

TOBACCO MOTH AND CIGARETTE BEETLE IN STORED TOBACCOS

The effectiveness of pyrethrum powder, applied at weekly intervals in open-storage tobacco warehouses, for controlling adults of the tobacco moth was further studied. Several important limitations to its use were noted, such as the slow reduction in populations, the undesirable coating of pyrethrum powder on the hogsheads at the end of the season, the large number of eggs laid by the female moths after the dusting, and the fact that pyrethrum does not kill the eggs, larvae, or pupae of the moth.

Experiments with the fumigation of tobacco with hydrocyanic acid gas at reduced pressures showed that complete mortality of the tobacco moth and cigarette beetle was obtained under summer conditions, whereas unsatisfactory controls were obtained under winter conditions. Tests in the fumigation of open-storage warehouses temporarily sealed showed promising results when dosages of 6 and 8 ounces of the hydrocyanic acid per 1,000 cubic feet were used, with an exposure of 24 hours.

THE TOBACCO FLEA BEETLE

Experiments on the control of the tobacco flea beetle in plant beds in South Carolina showed that paradichlorobenzene was not an effective remedy against this pest. The material was applied daily by spreading it on a shelf attached to the inside of the board side walls of the bed at rates up to 2 ounces per square yard of plant bed. Additional tests with insecticides showed that a dust mixture containing 1 percent of rotenone or a cryolite dust mixture containing 80 percent of sodium fluoaluminate gave good protection of the plants from injury by the tobacco flea beetle. However, the cryolite gave the best protection over a period of 6 days.

A study of the seasonal habits of the tobacco flea beetle on flue-cured tobacco showed that heavy infestations of this pest may kill the newly transplanted tobacco or damage it to such an extent that it will be slow in becoming established and beginning growth. The infestation on newly set tobacco may also be an indication as to the subsequent intensity of beetle infestation and damage on the tobacco approaching maturity. The studies showed also that newly transplanted tobacco, particularly in the Piedmont area of North Carolina and Virginia, is infested by the beetle at two separate periods, first, soon after transplanting and again in about 2 or 3 weeks. The first infestation is by overwintered beetles, while the second is by beetles from the new generation coming from sources outside the field. Although the beetle breeds on several species of plants, the only ones found to be of any great importance are tobacco, potato, tomato, and

black nightshade (*Solanum nigrum* L.). Of these, tobacco and potato appear to be of greatest importance as a source for the early-season breeding of the beetle.

Intensive studies were conducted in North Carolina to determine the relative importance of tobacco plant beds and of potato fields as breeding places of the flea beetle. An average of 250.8 beetles per square foot of tobacco plant bed and 91.5 beetles per square foot of potato row emerged during May and June from plants that had been naturally infested by beetles. In the cages containing artificially infested plants there was a positive relationship between the numbers of beetles emerging and the numbers introduced initially. These data show that both tobacco in plant beds and early potatoes are of great importance as breeding hosts of the beetle during the early part of the season. Considering the total areas devoted to each of these crops, however, tobacco plant beds are undoubtedly of much greater importance as breeding grounds of the beetle than early potatoes. The beetles emerging in plant beds soon left the beds and moved to the fields of newly set tobacco.

In the spring of 1940 further experiments were conducted to determine the effectiveness of several treatments designed to eliminate or reduce the importance of the tobacco plant bed as a breeding ground of the beetle. These studies corroborate those of 1939 as to the importance of the plant bed as a breeding source during the early part of the year, and they also indicated several promising possibilities for reducing its importance. For example, during June an average of 432.6 beetles per square foot emerged from an open plant bed to which no control measures against the beetle had been applied. By destroying the tobacco plants remaining in the bed after all transplanting was complete, and before emergence of the beetles began, the numbers of beetles to emerge was reduced 70 percent. Other valuable means of reducing the beetle productivity of the plant beds included the application of insecticides at regular intervals during the plant-bed season and the use of beds constructed and covered so as to exclude beetles during the early part of the plant-bed season.

SWEETPOTATO WEEVIL CONTROL AND ERADICATION

Cooperating Federal-State control and eradication activities against the sweetpotato weevil were continued during the year in areas of commercial production where wild host plants do not persist throughout the year, in the States of Alabama, Georgia, Mississippi, and Texas. The activities, which were supplemented by State-sponsored W. P. A. projects in Alabama, Georgia, and Mississippi, consisted of the destruction of infested seedbeds throughout the control areas, and of volunteer sweetpotato plants on infested and adjacent properties. Storage places were cleaned of host materials. During the year four counties were released from quarantine, all infestations having been eliminated. These counties were Gregg and Shelby in Texas and Lawrence and Jeff Davis in Mississippi. The regulations of the standardized State quarantines were strictly enforced and the States otherwise materially assisted in the conduct of control and eradication operations. Twenty-two counties in the four States mentioned were inspected during the year. Initial surveys in north-central Texas and southern Arkansas resulted in finding no weevils in these areas.

COTTON INSECT INVESTIGATIONS

BOLL WEEVIL

The damage by the boll weevil in 1939 was similar in amount and geographical distribution to that of 1938. The severe damage reported last year along the Atlantic seaboard continued in Virginia, North Carolina, Georgia, and Florida, and extended into parts of Alabama and Mississippi in 1939. The average loss was estimated at 32 percent in Virginia, the highest ever recorded from that State, and at 23 percent in North Carolina, or slightly less than in 1938. In South Carolina the hot, dry growing season was very unfavorable for weevil development and reduced the damage for the State to 8 percent, or only one-half of that of the previous year. The damage was also below average in all the States west of the Mississippi River where deficiencies in rainfall prevailed. The average reduction from full yield caused by the boll weevil for the United States in 1939 was estimated at 8.7 percent, or 1.2 percent less than in 1938 and slightly below the 10-year average.

The general conditions of weevil abundance and damage in representative sections are also shown by the gains secured from control measures. The increase in yields secured from treating plots in different sections with the standard calcium arsenate dust after 10 percent of the squares became infested is becoming of more value as an index of weevil damage as the records are accumulated over a period of years. At Florence, S. C., the average gain in 1939 was 315 pounds of seed cotton per acre; at State College, Miss., 661 pounds; at Tallulah, La., 221 pounds as compared with a 20-year average of 305 pounds; and at Waco, Tex., only 31 pounds per acre.

Light defoliations by leaf worms allowed the weevils to continue developing late into the season and above normal numbers to enter hibernation in the fall of 1939. At Tallulah, La., 189 live weevils per ton of Spanish moss were found as compared with an average of 54 during the previous 4 years. The expected heavy carry-over of weevils into 1940 was fortunately changed by the unusually low temperatures during January. At Tallulah there were freezing temperatures for 20 successive days and a minimum of −8° F. was the coldest ever recorded at that station, and practically all weevils hibernating in Spanish moss, cornstalks, and similar open shelter were destroyed. The emergence in hibernation cages with Spanish moss and cornstalk shelter was only 0.01 percent, the lowest ever recorded. No live weevils were found in the spring examination of Spanish moss collected from woods near cotton fields in several sections of the State. At Florence, S. C., with a minimum temperature of 13° F., the survival was 0.08 percent. Lower temperatures and survival occurred at Florence in 1936. The survival in cages at Leesburg, Fla., was 11 percent, and at Waco, Tex., 0.09 percent. Previous records are not available for comparison at the latter places. However, weevils hibernating in surface trash were protected from the cold by a heavy covering of snow over a large part of the Cotton Belt, and examinations of woods trash from near cotton fields showed that weevils had survived in protected places. Trash examination at Tallulah showed an average of 2,243 weevils per acre last fall and 190 in the spring of 1940, or a survival of 8.5 percent as compared

with 15 percent in 1939. Similar examinations at Florence in the spring of 1940 showed 176 live weevils per acre in comparison with 3,582 in 1939. In general the unusually cold weather reduced the weevil carry-over in 1940 to the lowest point in many years. The examination of woods trash during recent years by means of specially designed machines has proved of great value in determining the effects of climatic conditions on hibernating weevils and the overwintering populations. A cold, late spring also caused later than average emergence. At Florence daily collections of weevils in a trap plot of cotton showed that 40 percent appeared after June 14 when squares were present for oviposition, in comparison with 34.6 percent during the preceding 3 years. At Leesburg no weevils were found in a trap plot of cotton until June 7, or after squares were large enough for food.

Tests with calcium arsenates of different chemical and physical properties were continued in an endeavor to determine the most effective calcium arsenate for boll weevil control. Considerable variations exist as between different brands of commercial calcium arsenate, and as these can be controlled in the process of manufacture the discovery of more desirable properties should lead to the manufacture of a calcium arsenate giving better control at no increase in cost. Experiments with calcium arsenate containing low, intermediate, and high percentages of water-soluble arsenic pentoxide as determined by the New York method, similar to those reported last year, were repeated in randomized plots in South Carolina, Florida, Mississippi, and Louisiana, making a total of 68 replications for each treatment for the 2 years. The results were similar to those of 1938 in that no significant differences were found, either in boll weevil infestations or in yields, in field plots treated with calcium arsenate containing 0.5, 4.6, and 10.3 percent of water-soluble arsenic pentoxide as determined by the New York method. In cage tests the calcium arsenate containing the highest percentage of water-soluble arsenic pentoxide was again most effective against the boll weevil. The discrepancy between the results in the field and in cages is thought to be due partly to the differences in aphid populations following the use of calcium arsenate, as higher aphid infestations occurred in the plots treated with the higher percentages of water-soluble arsenic pentoxide.

In plot experiments at Tallulah, La., State College, Miss., and Florence, S. C., with mixtures of calcium arsenate and sulfur (1 to 1 and 1 to 2), the infestations and yields were about equal to those occurring where undiluted calcium arsenate was used in controlling the boll weevil. These mixtures have the advantage of reducing the numbers of sucking insects and the amount of arsenic added to the soil. In cage tests sulfur and calcium carbonate appeared to be better diluents for calcium arsenate than lime.

Cryolites containing 33, 81.3, 83.8, and 89.3 percent of sodium fluoaluminate were tested as substitutes for calcium arsenate in boll weevil control. The cryolite with 89.3 percent of sodium fluoaluminate caused severe burning of foliage in some cases, though this was avoided and a slight increase in toxicity secured by the addition of 1 percent of Lethane spreader and sticker. The cryolites with the higher per-

centages of sodium fluoaluminate gave better control than those with the lower percentages, but improvements are needed in dusting qualities to secure the thorough coverage of the plants that is necessary for weevil control. Although calcium arsenate or mixtures of calcium arsenate and sulfur gave better control and larger gains than any of the four cryolites tested, cryolite might be sufficiently toxic to control the weevil if the dusting qualities could be improved. The fluosilicates of barium and sodium were likewise not so effective against the boll weevil as calcium arsenate.

Interest in the use of sweetened poison (1 pound of calcium arsenate, 1 gallon of molasses, and 1 gallon of water applied with a mop) for boll weevil control has continued in some of the Eastern States. Since no dusting machinery is required, applications can be made at any time of the day, and the cost per acre is low. Tests have therefore been carried on over a period of years at Florence, S. C., in which the effectiveness of applying sweetened poison, or "mopping," has been compared with that of the standard treatment of dusting with calcium arsenate after 10 percent of the squares have become infested, and with that of mopping followed by later dusting. Over the 12-year period of these tests (1928–39) boll weevil damage ranged all the way from severe to very light. The average gains over the untreated checks during this period were 40.6 pounds of seed cotton per acre, or 5.2 percent, for the mopping; 275.8 pounds, or 30.4 percent, for dusting with calcium arsenate; and 316 pounds, or 38.4 percent, for the combined mopping and dusting. The average costs per acre per season for these three methods were, respectively, approximately $1.24, $3.67, and $4.26. In South Carolina with about 1½ million acres of cotton, enough molasses was reported sold in 1939 to mop 500,000 acres three times during the season. Assuming that the average difference of 235 more pounds of seed cotton per acre from dusting than from mopping could have been obtained on this acreage, the farmers lost some 80,000 bales of cotton in 1939 by using sweetened poison instead of the more effective calcium arsenate dust.

In the sea-island cotton areas of Georgia and Florida the weevil infestations were light early in the season, but severe boll damage was caused by the late-season migrating weevils. At Tifton, Ga., attempts were made to develop a timed schedule of dusting based on the squaring date of the cotton plant and predetermined intervals between applications that would not require infestation records to be made. Results, based on the percentages of squares infested and the damaged locks of harvested cotton, were equal to those from dusting after the usual 10 percent infestation. Plots sprayed with calcium arsenate gave fair control early in the season but again failed to give adequate control late in the season in both States. Mixtures of calcium arsenate and sulfur dusts were not so effective as undiluted calcium arsenate for weevil control, and while the increases in yields from the mixtures were larger than from calcium arsenate at Gainesville, Fla., part of the gains were probably due to control of other insects. The application of sweetened poison, or "mopping," also failed to give effective control in the experimental plots or when used by growers on a field basis in a number of fields under observation.

SOIL INJURY FROM CALCIUM ARSENATE

The investigations conducted in cooperation with the Mississippi Experiment Station on the effect of arsenic on productivity of some of the major soil types of the Cotton Belt were discontinued and the results published during the year. The yields of cotton in field plots on Houston clay loam, Memphis silt loam, Sarpy silty clay loam, and Sarpy fine sandy loam were unaffected even from an application of 1,600 pounds of calcium arsenate per acre. On Ruston sandy loam a beneficial effect was obtained from light applications of 50 to 100 pounds of calcium arsenate per acre although a detrimental effect was caused by heavier applications. The arsenical toxicity was reduced with time, and 4 years after the calcium arsenate was applied the plot that had been given the 400-pound dosage also gave an increase in yield over the untreated check while those given the 800- and 1,600-pound treatments had lost much of their toxicity. The ability of the unaffected soils to render arsenic insoluble was probably due to their high pH and their high colloidal content.

The effect of arsenic on the germination, seedlings, and production of cotton, corn, soybeans, hairy vetch, Austrian peas, and oats was studied on seven important soil types. Neither germination nor seedlings were injured on any soil until 400 pounds or more of calcium arsenate per acre were applied. The extent of the seedling injury from heavier applications depended on the soil type and crop, and was greatest in the Cahaba, Norfolk, and Ruston sandy loam types that contained the smallest amounts of clay, iron, aluminum, calcium, and magnesium. Crop yields from oats, Austrian peas, and hairy vetch planted immediately after calcium arsenate was applied and 1 year later showed that yields were affected by the application of 400 or more pounds per acre, but that much of the toxicity was lost in 1 year's time. Oats were more sensitive to arsenic than the other crops, but all were injured more on the lighter soils than on the heavier Houston clay loam, Memphis silt loam, Sarpy fine sandy loam, and Orangeburg fine sandy loam. Since the yearly application of calcium arsenate for the control of cotton insects is rarely more than 30 pounds per acre and since much of it is lost every year, accumulations of arsenic will probably never be sufficient to injure the crops usually grown on the soils studied.

LEAF APHIDS

The increase in aphid populations following the use of calcium arsenate is a serious disadvantage to its use against cotton insects and is seemingly becoming more important. In field plots at Tallulah, La., an average additional increase of 90 pounds of seed cotton per acre was obtained by also controlling the aphids where calcium arsenate was used for the boll weevil. There was also a definite correlation between aphid populations and the effectiveness of the insecticides used against the boll weevil and the leaf worm, the greatest number of aphids being found in the plots treated with the most effective insecticides. Attention was given to means of overcoming the aphid damage by developing aphid-resistant varieties of cotton, by decreasing through the use of diluents the amount of arsenic used, and by adding aphicides to calcium arsenate. In the selections of cotton for aphid

resistance no fully immune plant has yet been found. Individual plants selected from the same parent stocks in 1938 for variations in aphid abundance were self-fertilized and the seed planted to individual rows in 1939. The selections for light aphid populations produced progeny in the ratio of 2 light infestations to 1 intermediate infestation, while from the selections for heavy aphid infestation the ratio was 3 lightly infested, 7 intermediate, and 2 heavily infested. The variations in aphid populations appear to be associated with the physical characteristics of the plant rather than due to invisible factors of immunity. Studies of the physiological effects of calcium arsenate on the plant and on the aphids showed that dusting with calcium arsenate increased the pH value of the cell sap of the plant, and this in turn was positively correlated with the increase in aphid populations. In the experiments with diluents, the effect on aphids of adding sulfur to calcium arsenate has not been definitely established. In some localities last season this mixture seemed to reduce the aphid population while in others the addition of sulfur had little effect on aphid abundance. Further investigations are needed to determine the causes for these variations and the effects of sulfur, since the sulfur-arsenical mixtures are being extensively used against several cotton insects.

In experiments with aphicides added to calcium arsenate and cryolite to prevent the increase of aphids, better results were obtained with derris containing 0.5 percent of rotenone than with nicotine bentonite or nicotine bentonite-tannate. When enough derris was added to calcium arsenate, to mixtures of calcium arsenate and sulfur or diatomaceous earth, and to cryolites at the beginning of the season so that they contained 0.5 percent of rotenone, they remained sufficiently effective throughout the experiments to prevent a damaging aphid infestation from developing.

ROOT APHIDS

Experiments on control of cotton root aphids were limited to the use of poisoned baits for the attending ants that place them on the roots of cotton. Sweetened baits made with thallium acetate and thallium sulfate distributed in small aluminum bait cans about 10 feet apart on every third row gave effective control of the ants. A bait composed of ½ of a pound of tartar emetic, 1 quart of cane sirup, and 1 pound of sugar to a gallon of water, absorbed by sawdust or cottonseed hulls and distributed in small handfuls under the plants, likewise gave good control and was more economical and practical. Sawdust was less satisfactory than cottonseed hulls as a carrier for the bait. Twelve pounds of hulls will absorb about 2½ gallons of bait and is sufficient for treating 1½ to 2 acres of cotton. Best results were obtained by applying the bait just as the cotton began to break through the ground and on warm sunny days following cool nights on ground that had been packed by rain.

Root aphids feed on many of the common cultivated and wild plants and are more abundant on cotton following crops in which weeds develop during the fall and winter than in clean-cultivated crops. Studies were made of the abundance of root aphids on various soil-improvement crops and of crop rotations that will reduce their damage to cotton.

COTTON FLEA HOPPER

There was a light infestation of the cotton flea hopper in Texas in 1939 and consequently the gains from control experiments were low. In the 1-acre field plots at Port Lavaca the highest gain was 100 pounds of seed cotton per acre as compared with a maximum gain of 680 pounds in 1938 when a heavy flea-hopper infestation existed. In the Waco, Tex., experiments the highest gain was 189 pounds of seed cotton per acre from dusting with a 1 to 2 mixture of calcium arsenate and micronized sulfur applied at the rate of 7½ pounds per acre per application during the middle of the day while the cotton was dry. In that section, where high winds and light dews make dusting conditions unfavorable, micronized sulfur was more effective than the ordinary 325-mesh ground sulfur when used alone or in mixtures with calcium arsenate. Wettable micronized sulfur applied as a spray at the rate of 15 pounds per acre also gave promising results although the infestation was too light for definite conclusions to be drawn from this method of application.

Four varieties of cotton with different plant and growth characteristics were planted in Latin squares at Port Lavaca and at Waco for a study of resistance to the flea hopper. The average seasonal infestation at both locations was more than twice as high in the most susceptible as in the most resistant variety. There was also a marked varietal difference in the injury by flea hoppers in untreated cotton and some indication that insecticides were more effective against the flea hopper on some varieties than on others.

HEMIPTEROUS INSECTS

The investigations on the control of hemipterous insects attacking cotton have caused the growers of Arizona to become very insect conscious and aroused a great demand for information on dusting on a large scale applicable to their conditions. Although power-driven ground dusters would probably be more economical to operate, the irrigation schedules interfere seriously with their use, as on some soils ground machines cannot be used for several days on account of muddy conditions. When cotton reaches its maximum growth during the latter part of the season the insect population is usually at its peak and material damage to the plants is caused by the machine. Also sudden migrations of insects from other crops to cotton require quick applications of insecticides over large acreages. The use of airplane dusters promises to meet these requirements. During 1939 a large-scale airplane experiment was conducted cooperatively with growers, whereby they were to furnish the airplane and insecticide and the Bureau the entomological supervision, to obtain information on the efficiency, practicability, cost, and minimum populations of insects that would justify airplane dusting.

The species present were the same as those reported last year. However, *Dysdercus mimulus* Hussey was very scarce and *Creontiades femoralis* Van D. was much more abundant than in the past, greatly outnumbering the two species of *Lygus* which were formerly the most abundant and destructive mirids. Eight fields of 40 or 80 acres were selected representative of areas that were lightly and heavily infested in previous years. Half of each field was dusted with 7½ percent of paris green and 92½ percent of sulfur and half left untreated.

Seven applications of 15 pounds per acre were made in most of the fields at an average cost of $1.17 per acre per application. From the experience gained it is believed, however, that four applications would have been sufficient in most cases. Weekly records of the insect populations and form counts showed that the insects in some fields did not reach what are considered to be commercially damaging populations, and in no fields were the populations very heavy. However, the experiment was carried through as planned, since one of the aims was to determine what insect population would show a profit from control operations. Increases in yields ranging from 2.5 to 40.4 percent were obtained. In the five fields of short-staple cotton the gain was 123 pounds of seed cotton per acre, or 6.9 percent; in the fields of long-staple cotton the gain was 152 pounds, or 20 percent. The population and yield records indicate that while some increase in yields could be secured from dusting when infestations were light, control by airplane would not be justified unless at least 12 to 15 bugs of the injurious species could be collected with 100 strokes of a sweep net.

BOLLWORM

Most of the bollworm damage in the experimental plots at Waco, Tex., was caused late in the season by the second generation of worms on cotton. Special attention was given to the use of cryolites for control. Cryolites containing 97, 90, 83, and 30 percent of sodium fluoaluminate and lead arsenate dusts gave nearly equal control, with increases in yields ranging from 316 to 387 pounds of seed cotton per acre, or 110 to 126 percent, over the checks. A cryolite-sulfur dust containing 16½ percent of sodium fluoaluminate increased the yield only 29 percent. Barium fluosilicate and calcium arsenate gave increases of 64 and 56 percent, respectively. In laboratory tests where cotton leaves, cotton squares, or sliced cotton bolls were dusted with the same insecticides that were used in the field tests, from 20 to 100 percent mortalities of second- and third-instar bollworms occurred within 120 hours. In some tests with cryolite and calcium arsenate 100 percent mortality was secured with no noticeable signs of feeding on the dusted material as compared with only 5 percent mortality in the checks. The highest mortality in these tests always occurred where heavy applications were used, although more feeding was noted with the light and intermediate applications.

PINK BOLLWORM

A light carry-over of pink bollworms from the 1938 crop and an early maturity of the 1939 cotton resulted in lighter infestation and damage in the Big Bend area of Texas than at any time in recent years. Sufficiently heavy infestations for insecticidal control did not develop until very late in the season, and the large-scale dusting experiment was postponed. Pink bollworms in infested bolls under hibernation cages survived the winter of 1939–40 at Malaga, N. Mex. This is the first positive record of winter survival of the pink bollworm in New Mexico or in the slightly infested adjacent areas in Texas, or in Arizona.

In experiments in cultural control the planting of quick-maturing eastern varieties of cotton developed for boll weevil conditions,

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combined with close spacing and withholding of late-season irrigation water, produced less than one-third as many worms during the season as did the slow-maturing variety generally used in the irrigated sections of the Southwest. Of the various winter cultural practices for reducing the survival of hibernating larvae, deep plowing early in the winter followed by irrigations again gave the best control. A date-of-planting experiment in which cotton was planted March 28, April 20, and May 15 under a large cage showed that although delaying planting decreased the initial infestation because moths emerged before squares were available for larval food, it also increased the populations entering hibernation in the fall owing to later maturity of the crop.

Of the 33 domestic and foreign strains of okra planted at Presidio, Tex., to determine whether any were immune to pink bollworm attack, 32 strains produced pods and all became infested. Larvae were found to attack the flower buds and 1-day-old pods, and larvae that were immature at the time pods were collected developed into normal moths when stored under favorable conditions for insect development.

Special attention was given to biological studies to determine how and where the pink bollworm passes the winter in the lower Rio Grande Valley. Larvae were found in green fruiting forms of cotton until all the cotton was killed, about the middle of January 1940, and again when pods became available in May. There seems little doubt that breeding will continue throughout the winter if normal conditions prevail and food is available. Some larvae entered the resting stage as early as July, but the time of moth emergence could not be determined because of quarantine restrictions. Resting-stage larvae were found in old bolls and locks of cotton on plants and on the soil surface, or buried in the soil, throughout the winter and until April 1940. No larvae were found in loose cocoons in the soil as is the case in the Big Bend. About 50 species of malvaceous plants occur in the region but none was found infested except okra and Turk's cap (*Malvaviscus drummondii*). Large quantities of seed pods of *Hibiscus cardiophyllus*, a known host, were examined with negative results.

Rearing of *Microbracon kirkpatricki* Wilkn., which was discontinued in 1938 after this parasite's failure to become established at Presidio, was resumed through breeding stock obtained from Egypt by the Division of Foreign Parasite Introduction. This species readily attacks boll weevil larvae under laboratory conditions, and liberations will be continued at Brownsville, Tex., where both the pink bollworm and the boll weevil occur and conditions are more favorable for establishment than in the Big Bend. A total of 306,500 adults of *Chelonus blackburni* Cam. were liberated during the year in the Presidio and lower Rio Grande Valleys of Texas. A heavy mortality occurred in the cocoons of *Microbracon nigrorufum* Cush. held in cold storage over winter, and only one colony was liberated at Brownsville.

PINK BOLLWORM CONTROL AND QUARANTINE ENFORCEMENT

The outstanding accomplishment in connection with pink bollworm control during the 1939 season was in connection with cottonfield clean-up on approximately 400,000 acres in the southern part of Texas.

The most important developments in connection with the status of infestation were the increase in infestation in the lower Rio Grande Valley counties of Texas and Mexico, spread of infestation from that region to additional southern and southwestern Texas counties, and the development of light infestations in several additional west-central counties of Texas in the vicinity of San Angelo and Colorado. Control measures practiced in the eastern end of the Salt River Valley resulted in there being practically no infestation in that part of Arizona in 1939, but a fairly heavy infestation was found in a limited area in the Glendale section north of Phoenix, in Maricopa County. Outstanding results were obtained in connection with intensive control which was practiced in the Big Bend of Texas and Mexico in 1938 and 1939, as infestation in that area was decreased to such an extent that no commercial damage was experienced, whereas in previous years from 50 to 75 percent of the crop had been destroyed by the pink bollworm.

CONTROL PROGRAMS IN THE VARIOUS REGULATED AREAS

LOWER RIO GRANDE VALLEY AND COASTAL BEND AREAS

A special appropriation was made by the Congress for conducting a comprehensive clean-up program in the lower Rio Grande Valley and Coastal Bend areas in southern Texas. An intensive clean-up was conducted in a limited area of approximately 12,000 acres in the vicinity of Brownsville, Tex., because the pink bollworm infestation had built up in that section until it was possible to find as many as 1,000 pink bollworms in the trash from 1 bale of cotton. The clean-up measures practiced in the remainder of the infested counties in southern Texas consisted in the immediate destruction of cotton stalks following harvesting of the crop so as to stop the propagation of the pink bollworm. The farm operators themselves destroyed the plants and were reimbursed in part by the Federal Government for the cost of this operation. In those areas in which rank-growing stalks occurred a flat payment of 75 cents per acre was made and in the rest of the area, where the plants do not grow so rank, a payment of 50 cents per acre. This early destruction of plants was followed by an intensive program which had for its purpose the elimination of volunteer cotton growing in abandoned places in an almost wild state. This volunteer cotton had to be eliminated from the areas to prevent it from serving as a winter host for the pink bollworm. The additional counties in southern Texas found infested late in the summer of 1939 were not included in the original control program, so a volunteer stalk-destruction program was undertaken in those counties with a fair degree of success, although the destruction of plants was not effected so promptly as in the old regulated areas where the farmers were partly reimbursed for the cost of the job.

BIG BEND AREA OF TEXAS

An intensive control program designed to reduce the degree of infestation of the pest in the Big Bend area of Texas was inaugurated early in 1938. This program called for early planting of the crop during that year so that the plants might be destroyed early in the fall following the harvest. It was thought that this early destruction

of plants would result in a lower overwintering population and that in consequence fewer moths would emerge from hibernation early in the season to infest the 1939 crop. The State of Texas issued a regulation prohibiting the planting of cotton on the Texas side until April 20, and a similar regulation was enacted on the Mexican side. As a result, there was a period of warm weather while the moths from hibernating larvae were emerging but no cotton upon which they could lay their eggs. The only clean-up in 1938, followed by the host-free period in the spring of 1939, proved of enormous benefit, as infestation did not develop to a damaging extent in the 1939 crop. Owing to cultural and other practices it was possible to make a relatively early clean-up again in 1939, and planting was delayed in the 1940 crop until April 20, as was the case in 1939.

ARIZONA

An intensive clean-up in the Gilbert area of Arizona following the harvesting of the 1938 crop had significant results, as indicated by the absence of appreciable infestation in that region for the 1939 crop. A similar intensive clean-up was conducted in the Glendale section of the Salt River Valley, following the finding of a rather heavy infestation in a limited area in that section in the 1939 crop. The State of Arizona again participated in the clean-up in the Salt River Valley in the vicinity of Glendale, as they had done the previous year near Gilbert. To carry forward the advantage gained in the reduction of the pink bollworm population in the Salt River Valley, a program was inaugurated in the spring of 1939 through the cooperation of the Agricultural Adjustment Administration of the United States Department of Agriculture and the State of Arizona whereby all stub or volunteer cotton had to be destroyed by the owners of the land prior to May 10, 1940. The destruction of this stub or volunteer cotton prevented it from serving as a host for the pink bollworm early in the season before the 1940 planted cotton became available for oviposition by moths. All growers having an A. A. A. allotment cooperated, and it was necessary for the Federal and State Governments to destroy stub cotton on less than 1,000 acres upon which there was no A. A. A. allotment.

QUARANTINE ENFORCEMENT

TREATMENT OF PRODUCTS FOR CERTIFICATION

A total of 765,235 bales of cotton were produced at the 448 gins located in the pink bollworm regulated areas of Arizona, New Mexico, and Texas, and 343,882 tons of seed were sterilized in compliance with State and Federal pink bollworm regulations. The 41 oil mills within the areas handled 276,174 tons of seed. The 12 compresses under supervision compressed 610,448 bales of lint in compliance with the pink bollworm regulations. Cotton linters in the amount of 17,835 bales were treated by passing the lint bat between steel rollers so as to crush any insects which might be present therein. Three hundred and thirty-five bales of Mexican linters were fumigated upon arrival in the United States, under the supervision of the Division of Pink Bollworm Control. It is believed that the strict supervision of the processing and treatment of cotton

products originating in the pink bollworm quarantined areas before they were allowed to be moved to noninfested areas prevented the spread of the pink bollworm by carriage in such products.

VEHICULAR INSPECTION TO PREVENT SPREAD OF THE PINK BOLLWORM

To determine whether the quarantine is being violated, vehicles on highways leading out of the regulated areas must be inspected. Another object of this inspection is to prevent the movement of small lots of seed cotton by transient cotton pickers leaving the regulated areas to go into noninfested regions to pick cotton. The fact that hundreds of lots of seed cotton were removed from cotton-pick sacks during such inspection is believed to show its primary importance in preventing the spread of the pink bollworm.

INSPECTION FOR THE PINK BOLLWORM IN REGULATED AREAS

Gin-trash inspection in the 1939 cotton crop in the lower Rio Grande Valley indicated that the pink bollworm infestation had built up to a considerable extent, particularly in the area near Brownsville in Cameron County. There was a noticeable increase in the number of pink bollworms found in Hidalgo County as well, but infestation in the Coastal Bend counties of Texas in the vicinity of Corpus Christi had not increased to any considerable extent over that in 1938. Gin-trash inspection in the 1939 cotton crop in the irrigated valleys of western Texas, New Mexico, and Arizona indicated that the infestation, as a rule, was much lighter in those areas than in 1938, and this appeared to be directly attributable to the tremendous decrease in infestation in the Big Bend area of Texas and Mexico. Infestation in the southern plains of Texas was lighter in the 1939 crop than in that of 1938. As a result of the finding of pink bollworms in the 1939 crop, the counties of Dimmit, Duval, Frio, Jim Hogg, La Salle, Maverick, Webb, Zapata, and Zazala in southern Texas were added to the regulated area and the counties of Tom Green, Concho, and Mitchell in west-central Texas were also added to the quarantined area because of spread of infestation into those areas. A summary of the amount and results of the various types of inspection in the regulated areas, including those counties added to the area in 1939, is shown in table 9.

TABLE 9.—*Summary of inspections for the pink bollworm in regulated areas, crop season of 1939*

State	Gin trash		Field		Laboratory [1]	
	Quantity	Pink bollworms	Man-days	Pink bollworms	Green boll samples	Pink bollworms
	Bushels	*Number*	*Number*	*Number*	*Number*	*Number*
Arizona	38,245	94	0	0	0	0
New Mexico	798	1,048	0	0	0	0
Texas	47,838	19,051	0	0	92	692
Total	86,881	20,193	0	0	92	692

[1] Laboratory inspection covers bolls collected from the 1938 crop.

INSPECTION OUTSIDE OF REGULATED AREAS

Gin-trash inspection is concentrated each year in areas adjacent to known infested areas in order to disclose any spread of the pink bollworm from regulated areas while still in the incipient stage, so that build-up and wider distribution of the infestation may be prevented. As a result of such inspection of the 1939 crop, a light infestation was found in several counties, and these were added to the regulated areas and listed under that heading. Inspection of gin trash was also carried on in the southwestern part of Louisiana and in practically every county in Mississippi where any appreciable amount of cotton is grown, and practically all trash from the northern part of Florida and the southern parts of Alabama and Georgia was inspected. With the exception of Texas, results of all inspection in these States were negative as to pink bollworm infestation. There was also some gin-trash inspection in Mexico in the States of Tamaulipas, Nuevo Leon, Coahuila, and Chihuahua. A total of 7,483 specimens of the pink bollworm were taken through the inspection of 380 bushels of trash in the Matamoros area, which is at a somewhat lighter rate per bushel than was recorded in 1938. From the Reynosa area, examination of 564 bushels yielded 21 pink bollworms as compared with 9 from 322 bushels of trash during the 1938 season. In the Don Martin district of Nuevo Leon 6 pink bollworms were taken through the examination of 62 bushels of trash. This is the first record of infestation in the Don Martin area, which has been inspected annually for a number of years. In the Juarez Valley, in the State of Chihuahua, the same amount of trash was inspected in each of the last two seasons, and less than half as many worms were found in 1939 as in 1938.

A summary of the amount and the results of the various kinds of inspection is given in table 10.

TABLE 10.—*Summary of inspections for the pink bollworm outside of regulated areas, crop season of 1939*

State	Gin trash		Field		Laboratory [1]	
	Quantity	Pink bollworms	Man-days	Pink bollworms	Samples	Pink bollworms
	Bushels	*Number*	*Number*	*Number*	*Number*	*Number*
Alabama	1,850	0	0	0	0	0
Arizona	293	0	0	0	0	0
California	8,708	0	0	0	0	0
Florida	388	0	32	0	594	0
Georgia	2,683	0	43	0	468	0
Louisiana	1,273	0	0	0	0	0
Mississippi	7,677	0	0	0	0	0
New Mexico	0	0	0	0	15	0
Oklahoma	562	0	0	0	341	0
Texas	46,989	0	0	0	2,068	0
Total	70,423	0	75	0	3,486	0
Mexico:						
Chihuahua	31¼	2,435	0	0	0	0
Coahuila	0	0	0	0	49	3
Nuevo Leon	62	6	0	0	0	0
Tamaulipas	944	7,503	0	0	0	0
Total	1,037¼	9,944	0	0	49	3
Grand total	71,460¼	9,944	75	0	3,535	3

[1] Laboratory inspection covers bolls collected from 1938 crop.

WILD COTTON ERADICATION

A satisfactory season has been experienced in the program for eradication of the pink bollworm from southern Florida through the destruction of its host plant, wild cotton. During the season just brought to a close, some 22,000 less fruiting plants were found throughout the area than during the previous season, and the percentage of infestation now present on the plants being found was also greatly reduced. Owing to available manpower the wild cotton acreage was recleaned more times this season than during the preceding year. In the Bradenton and Fort Myers subdistricts there was a considerable increase in the number of seedling plants found, and there was a slight increase in the Ten Thousand Island section. It is believed, however, that this situation was brought about by the clearing of shrubs and undergrowth from wild cotton lands during the previous season, which permitted air and sunlight to reach dormant wild cottonseed on the ground.

During the past season all known wild cotton colonies were cleaned twice and a considerable portion of the area was cleaned 3 times; 24,218 plants with mature fruit, 1,330,044 seedlings, and 4,427 sprout plants were destroyed from approximately 39,000 acres. In addition, 32,791 acres were scouted and more than 3,000 trails were cut, which should greatly expedite future work. Funds to carry on the eradication of wild cotton were provided through W. P. A. allotments, together with funds allocated by this Bureau, and during the past season a company of C. C. C. enrollees was made available to assist in carrying on the work.

COOPERATIVE PINK BOLLWORM WORK, MEXICO

The presence of pink bollworm infestation in areas of Mexico immediately adjacent to the cotton-growing areas in the United States has necessitated a cooperative arrangement with Mexican officials in connection with the control of the pink bollworm along the United States-Mexico boundary line. Inspectors of the Division of Pink Bollworm Control and those of the Department of Agriculture of Mexico frequently confer and work out joint programs so that the control efforts of one agency will not be nullified by failure to inaugurate a similar program in the other country. As a result of these cooperative arrangements, similar control measures are practiced with respect to cottonseed sterilization, sanitation at the gins, and field clean-up measures in adjacent areas in the United States and Mexico. The effects of such cooperative arrangements have been especially beneficial in the lower Rio Grande Valley of Texas and Mexico, in the Big Bend region of Texas and Mexico, and in the Juarez-El Paso area.

THURBERIA WEEVIL CONTROL

The destruction of *Thurberia* plants in the Tortillita and Santa Catalina Mountains of southern Arizona was undertaken to prevent the spread of the Thurberia weevil, with which these plants were heavily infested, into adjacent domestic cotton plantings. During the year eradication work consisted of a recheck of these mountain ranges. Because of inadequate funds no equipment could be furnished for the maintenance of a camp in the mountains, as had been

done during a considerable portion of the time during previous years, and it was therefore necessary to transport laborers from Tucson to the mountains and back each day, involving between 60 and 70 miles of travel. During the year approximately 78,480 acres were covered and 290,777 *Thurberia* plants were destroyed. It is estimated that at least 95 percent of the *Thurberia* plants destroyed carried or showed damage by the Thurberia weevil. Since the inauguration of this project in 1935, a total of 376,650 acres have been covered and 2,055,539 *Thurberia* plants have been destroyed.

This project was brought to a close on June 15, 1940, because work had been completed on the area to be cleaned under the original program, and sufficient funds were not forthcoming to inaugurate a more comprehensive program. Funds to carry on this work have been provided by W. P. A. allotments, supplemented by funds allocated by this Bureau.

BEE CULTURE

POLLEN STUDIES

A correlation of the annual brood-rearing cycle of a colony of honeybees with pollen income has shown that the peak of egg laying occurs during the peak of pollen income. The spring peak of colony population was found to occur 5 weeks after the maximum pollen income. An ample supply of pollen during the 5-week period prior to the honey flow is therefore essential to maximum colony strength for honey production.

Experimental colonies equipped with pollen traps gathered 1 pound or more of pollen per day on several occasions during fruit bloom. The largest daily yield was 1 pound and 11 ounces, estimated to be equivalent to the loads of 128,665 bees. One colony produced 42.7 pounds of pollen during the active season, an amount that would require the labor of 1,767,665 bees making single trips. Since 1 bee visits from 80 to several hundred blossoms to obtain a load of pollen, the pollination service of a colony is enormous.

The pollen content of fresh nectar from 38 species of plants ranged from zero in 1 navel orange to 176,000 grains per cubic centimeter in *Amsinckia*. In nectar from deciduous fruits the pollen content ranged from 1,800 grains per cubic centimeter for peach to 11,000 grains for apple. The nectar of other important honey plants contained the following amounts: Black locust, 2,800; sages, 4,000 to 5,000; dandelion, 12,800; mustard, 21,000; Dutch clover, 42,400; and manzanita, 69,000 grains per cubic centimeter. The feeding of sirup containing no pollen to colonies having ample pollen reserves did not stimulate egg laying whereas after the addition of pollen to the sirup expansion in egg laying was noted within 24 hours. The pollen suspended in nectar and honey unquestionably influences brood rearing, for normal brood rearing requires both pure pollen and pollen suspended in the liquid food.

Bees show remarkable ability to remove suspended pollen contained in their honey stomachs. After 15 minutes' retention in the honey stomach a sirup containing 38,000 pollen grains per cubic centimeter was reduced to 29,000 grains and practically all grains disappeared in an hour.

Soybean flour supplemented by 25 percent of pollen stimulated brood production during February, March, and April. The overwintered

bees were replaced by young bees to such an extent that approximately 3½ pounds of young bees could have been removed for packages during the last week in April.

NECTAR-SECRETION STUDIES

Light, atmospheric pressure, and temperature influenced nectar secretion in greenhouse poinsettias. The sugar content of the nectar varied inversely with the relative humidity but directly with the amount of air movement, when the temperature remained constant. Tests indicate that the shape of blossoms, in addition to weather factors and differences in species of plants, may also contribute to differences in nectar concentration. In a saturated atmosphere sirups containing more than 38 percent of invert sugar tended to become more dilute, while those of lower sugar concentration tended to become more concentrated.

Laboratory studies on nectar secretion in alfalfa indicate that length of exposure to light influences the time of blossoming. The average raceme contains 16 blossoms, those at the distal end blooming about 4 days later than those at the base. The blossoms wither in about 7 days. The mature blossoms have richer nectar than the immature. The alfalfa blossoms yielded from 0.82 to 2.4 microliters of nectar, and from 15 to 45 blossoms were required to furnish 1 bee load. In contrast, orange blossoms yielded 30 to 40 microliters of nectar, and 1 to 1½ blossoms yielded a bee load. The nectar in the unopened orange buds contained 16 percent of sugar and that in open blossoms from 16 to 50 percent.

INVESTIGATIONS AND AMERICAN FOULBROOD

In the cooperative studies on the resistance of honeybees to American foulbrood, of 317 queens of resistant stock 78 percent either recovered or failed to contract the disease. In Iowa 347 queens were tested by beekeepers under conditions of infection normally existing in non-isolated communities.

Seventy-eight queens of strains having no history of resistance were tested at Hope, Ark. Since difficulty was experienced in obtaining infection in the few colonies developing disease, comparative tests with strains similar to those under test in Iowa and Wyoming have been begun to determine whether the climate or the honey flow influences the results.

The behavior of bees toward diseased remains indicates that resistance to American foulbrood is concerned with bee behavior and is not physiological in its nature. Primary infection takes place in young larvae 2 days or less after hatching, the infectious period coinciding with the initial feeding stage rather than with the later feeding stages, as had been supposed previously. This conclusion has been further substantiated by the inoculation of individual larvae. It has also been demonstrated that only relatively few spores per larva are required to produce infection, a matter of great importance to an understanding of the development and spread of this disease.

Spores of *Bacillus larvae*, the causative organism of American foulbrood, subjected to sublethal heating were found to be more exacting in their nutritive requirements in culture than were untreated spores. Unheated egg-yolk medium containing extract of dry yeast, carrot extract neopeptone, and dextrose gave excellent results. Spores boiled in water for 7 hours as well as those autoclaved at

15 pounds for 25 minutes grew in this medium. Less than one-tenth this amount of heating was formerly thought sufficient to destroy all spores of *B. larvae.*

INVESTIGATIONS OF ABNORMAL DEATH OF BEES IN UTAH

Field and laboratory investigations were started in May 1940, in cooperation with the Utah Agricultural Experiment Station, to determine the causes of the abnormal death of adult bees in Utah, variously claimed as resulting from insect-control operations, from the effects of smelter fumes, or from other causes. The territory affected in past years was surveyed and samples of dead bees and other materials were analyzed for arsenic. With a few exceptions, losses have not been so serious during the current year as in previous years, and analyses of bees have shown no outstanding cases of excessive amounts of arsenic.

CAUSES OF SPOTTED BROOD

Work during 1939 on the causes of spotted brood indicates that this condition is caused by irregular laying of eggs, characteristic of certain queens, and by a heavy brood mortality principally before the fifth day after egg laying. Such factors as population, availability of nurse bees to the total amount of brood, pollen reserves, and seasonal changes also influence this condition. Mortality varied greatly in colonies headed by queens of the same strain, and it is impossible as yet to state whether a high or low brood mortality is a characteristic of a given strain.

TESTS OF COMMERCIAL STOCK

Tests of 13 lines of commercial stock showed pronounced differences in production efficiency and queen losses, and indicate that the hereditary background of the stock is largely responsible for its performance. Honey yields for the different lines ranged from 60 to 160 pounds per colony above winter requirements. Colony yields ranged from 17 to 262 pounds for colonies that did not supersede their queens. The stock giving highest production was from the same source as the best stock tested in 1938. Seven of the thirteen lines were also compared in 1938 and, for the most part, the performances were similar during the two seasons. Queen losses amounted to 38 percent, the greatest loss occurring in those lines in which surviving queens headed medium to poor producing colonies. Four of the thirteen lines lost or superseded from 50 to 60 percent of their queens, whereas two lines had no loss.

In the spring of 1940, 42 percent of 139 queens shipped in cages and introduced into queenless packages required 2 to 6 days to begin egg laying, whereas queens shipped in packages began laying 12 to 18 hours after introduction. The delayed egg laying experienced with queens shipped separately probably is due to improper feeding during shipment. Delayed egg laying in turn is probably responsible for the heavy loss at introduction, which amounted to 10 percent of 267 queens used.

BIOCHEMICAL DIFFERENTIATION OF FEMALE CASTES

Biochemical investigation of the differentiation between the female castes of the honeybee has shown that queens and workers have

approximately the same growth rate during early life and then the growth of the worker caste is retarded, as shown by the amount of nitrogen, total lipid, total reducing substances, and calorific value. Queens attained a maximum live weight of more than 260 milligrams during development, as compared with 144 milligrams for the workers. Water comprised 76 to 85 percent of workers and 75 to 83 percent of queens during development. The queens reached a maximum nitrogen content of 5.7 milligrams per individual, while the workers reached only 2.2 milligrams. The highest total lipid content was 12.8 milligrams for queens and 5.4 milligrams for workers. Total reducing substances reached a maximum of 13.2 milligrams in queens and 12.1 milligrams in workers. The average ash content of the prepupal and pupal stages of the worker was approximately six times that of the queen. The calorific value of the tissues of both castes increased during the larval period and decreased during metamorphosis.

EFFECT OF FEEDING ON WEIGHT OF QUEENS

In a study of the effect of various factors upon the weight of the queen larva and the production of royal jelly, it was found that the weight of the larva was not correlated with the amount of food. It appears, therefore, that the prevailing effort among queen breeders to insure that the queen larvae be copiously supplied with larval food does not necessarily increase the weight of adult queens. Increasing the number of bees in a swarm box did not insure a proportionate increase in the amount of larval food, or an increase in the weight of the larvae.

PROGRESS IN ARTIFICIAL INSEMINATION

Considerable progress was made in the field of artificial insemination. It has been shown that etherization may cause queens to lay more than one egg to the cell. Comparisons of spermathecae of queens inseminated by various methods showed that the greater the amount of sperm injected at a single operation the greater the degree of insemination and that some method of closing the opening of the vagina with mucus from the mucus gland of the drone is important.

NOTES ON MATING

The twenty-fifth floor of a building was found unsuitable as an isolated mating station when other bees were on the ground in the vicinity.

Observations on natural matings show that approximately half of the queens of each of three strains mated twice, usually on successive days.

INVESTIGATIONS OF INSECTS AFFECTING MAN AND ANIMALS

SCREWWORMS AND BLOWFLIES

Sufficient experimental data were obtained on the use of the new chemical diphenylamine in protecting wounds of animals from screwworm infestations so that information regarding it could be given to stock owners. This information was released in the form of press notices and as a circular which gives instructions for the use of this chemical in screwworm control. The treatment has been rather

widely tried by stock owners, most of whom are enthusiastic about it. Experiments were conducted to find wound protectors even more effective than diphenylamine, and these tests involved the treatment of some 1,700 screwworm cases under field conditions. In addition, 133 other chemical compounds which appear promising as screwworm larvicides were given preliminary laboratory tests.

Reinfestations of a chemically treated wound with screwworm eggs have never been recorded so long as the wound was strongly acid or, in other words, maintained a pH value of 6.0 or below. On the other hand, oviposition increased at a pH value of 6.4 and continued to increase as the wound lost its acidity until maximum oviposition was reached when a wound showed a pH value of 7.0

In a search for fundamental factors involved in protecting a wound from screwworm attack it was demonstrated that repellency was one of the most important. It was observed repeatedly that the increase in protection afforded a treated wound was in direct ratio to the increase in repellency of the material used for treatment. For example, p-nitrophenetole showed a repellency of 69.5 percent and a wound protection of 19.96 days, pine-tar oil a repellency of 62.8 percent and a protection of 16.95 days, and diphenylamine a repellency of 42.7 percent and a protection of 14.68 days. Two of the materials, p-nitrophenetole and diphenylamine, are larvicides. The former is also an ovicide, whereas pine-tar oil has little if any ovicidal or larvicidal properties.

In experiments on larvicides and ovicides for destroying screwworms, it was found that benzene containing 5 or 10 percent thiophene, or 10 percent naphthalene, and undiluted tolvene is superior to undiluted benzene as a larvicide, while xylene and p-cymene are inferior. P-nitroanisole and o-nitrophenol killed 100 percent of the eggs of the screwworm fly.

Great variations in protection from screwworm reinfestation in like individuals treated with the same wound protector were observed, and were found to be due to the factor of the individual animal or its inherent disposition and reaction to fly attack.

HORN FLIES

Satisfactory results were obtained for the second season with the automatically operated cattle-fly trap. It was found that cattle quickly learned to use a trap to relieve themselves of flies, and infestations were reduced from 3,000 to 4,000 flies per head in untrapped pastures to 200 flies per head in trapped pastures.

To make this method of control available to stock owners, a circular was issued describing the use and construction of the trap. A public-service patent has been granted on this trap.

As a result of 68 tests with the medication of cattle for the prevention of horn flies breeding in their droppings, it was found that of the 29 chemicals used in these tests rotenone was by far the most effective. Rotenone, however, is expensive and for that reason may be impractical.

CATTLE GRUBS

In cooperation with ranch owners and the Texas Agricultural Experiment Station and Extension Service further studies were made on the control of cattle grubs in range animals. On some of these ranches where experimental control work is in the third year it was

observed that the grub population had been reduced about 84 percent in comparison with untreated herds in the same locality.

The possibility of using sulfur-cube dip in cattle grub control was investigated. This dip is now being used for louse control, and the advantage of a treatment with a dual purpose is obvious. Single dippings killed a low percentage of grubs, but two dippings at 17- and 19-day intervals killed 67.3 percent of them. This indicates the desirability of further experiments in which the number and interval of the dippings are varied.

EXTERNAL PARASITES OF SHEEP, GOATS, AND CATTLE

Progress was made in the study of wetting agents for increasing the efficiency of sulfur dips for the control of goat lice. Combinations of two or three different wetting agents were found to be superior to any single agent. Twenty such combinations can now be recommended as giving the maximum toxicity and better retention of sulfur on the skin and hair of the animal. Forty-nine other formulas tested were found undesirable.

In cooperative tests with local ranchmen approximately 7,000 head of cattle were dipped in a sulfur-cube dip for the control of the resistant, blood-sucking, short-nosed ox louse. This was determined as a satisfactory control. Tests were also initiated to determine the effect of feeding sulfur to infested animals for the control of lice. This treatment has frequently been advocated by stockmen and others. After 6 months the infested animals which received a daily ration of 5 grams of elemental sulfur for every 100 pounds of live weight continued to show louse infestation. Treated and untreated animals were placed in dark stalls for 3 months each, but no difference in louse infestation was noted, as has been sometimes claimed.

FLY SPRAYS

Sixteen new materials were tested against flies that are troublesome about dairies. Of these, 4 displayed toxicity to cattle but none of them exerted a sufficient effect on the flies to warrant further investigation. A total of 88 materials were tested for their poisonous effect on houseflies and only 6 were found which caused greater than 20 percent mortality in 24 hours. A total of 64 carbon compounds were tested to determine their repellency toward houseflies and only 4 of them showed strong repellent properties. These tests are being continued. It has been determined that the best method of preparing home-made fly sprays is to dilute the ordinary commercial 20-to-1, or 30-to-1, pyrethrum concentrate with kerosene, and that a good quality spray can be made in this way for approximately 42 cents per gallon. This method is probably more economical for the farmer than extracting the pyrethrum flowers himself.

MOSQUITOES

At the invitation of the Tennessee Valley Authority the Bureau cooperated with that organization and other Federal agencies to determine methods of controlling malaria mosquitoes which would not adversely affect wildlife in the Tennessee Valley. The following agencies were invoved: Tennessee Valley Authority, Fish and Wildlife Service, Public Health Service, and Bureau of Entomology and

Plant Quarantine. Studies were conducted of the effect on wildlife and wildlife food of the standard methods of malaria mosquito control, including fluctuation of water levels and the use of paris green and oils. As a result of this cooperative study a better understanding was obtained of many of the problems of mutual interest to malaria control workers and those concerned with fish and game conservation. Certain adjustments of the mosquito-control procedure were made and data were secured which will be useful in similar situations in other parts of the country. This cooperative study is being continued.

Investigations of salt-marsh mosquitoes were intensified along the east coast of Florida. Their purpose is the development of methods of control of salt-marsh mosquitoes which are more effective and less expensive, and at the same time will not adversely affect wildlife on the marshes. As a basis for this work, studies were begun to determine the little-known biologies of the species and their ecological relations. The more important preliminary results indicate that marshes where the grass *Distichlis* predominated produced the greatest number of mosquitoes, about 46 million larvae per acre; and where the plant *Juncus* occurs, about 30 million per acre. Observations showed that the greater the proportion of these plants in the marsh flora, the greater was the mosquito population.

Comprehensive studies on the development of more effective mosquito larvicides were begun at the Orlando, Fla., laboratory. During the year 76 chemicals were tested for their relative toxicity to mosquito larvae; 29 of these were toxic in concentrations of 20 parts per million or less and 6 in concentrations of from 2 to 5 parts per million.

The more important results of studies on the biologies of mosquitoes in the Pacific Northwest showed that eggs of *Aedes vexans* (Meig.) and *A. lateralis* (Meig.) would remain viable in the soil for at least 6 years. A study of the resistance of the various instars of mosquitoes to pyrethrum-oil emulsion showed that differences exist in mortality between instars of the same species and between those of different species. Larvae in the first and second stages were more quickly killed, and with less emulsion, than were those of the third and fourth stages. *Culex* and *Theobaldia* larvae showed greater resistance than did *Aedes* larvae.

CLEAR LAKE GNATS

As a result of investigations of the Clear Lake gnat in California an electric-light suction trap was developed that captures large quantities of gnats under certain weather conditions. Two such traps at the laboratory, 75 yards apart, took 1,750 pounds of gnats during the summer of 1939. Another trap, operated at Lucerne, took 800 pounds in a 48-day period. The daily catches ranged from 0 to 88¼ pounds. The latter catch was estimated to contain about 88 million gnats. From 50 to 90 percent of the larger catches were of females heavily laden with eggs.

Over 700 tests of larvicides, in which many different materials were used, were conducted on the gnat larvae. In the laboratory the larvae are killed by high dilutions of certain insecticides. Pyrethrum, phenothiazine, carbon tetrachloride, trichlorethylene, and certain mix-

tures of these have shown good results. Over 90-percent kill was demonstrated at a dilution of 1 to 6,000,000 of a 15 to 1 pyrethrum extract. A pyrethrum solution containing 1.0 gram of total pyrethrins per 100 cubic centimeters in Diesel oil and carbon tetrachloride gave good kills in a dilution of 1 to 10,000,000, and more than a 60-percent kill at 1 to 30,000,000.

Because the eggs of the gnat concentrate in huge drifts, very frequently along the shore, the use of an ovicide is promising. The New Jersey pyrethrum-oil emulsions destroy the eggs effectively in the laboratory, and a few field tests indicate that the destruction of a large percentage of the eggs can be accomplished with them under certain conditions.

INSECT SECRETIONS

Results of the year's investigations of insect secretions have had a far-reaching influence in the field of biology and medicine. These studies revived an interest in the enzyme urease. This enzyme, which is necessary to certain life processes, has been known for the last 80 years but has been largely neglected in the field of biology. Two additional extracts, designated respectively as "maggot extract F" and "maggot extract K," were discovered. The former promises to be of greater value in healing various types of wounds than any of those already found and now widely used in medical practice, and there has been a great demand for it by various clinics and hospitals. Although maggot extract K has as its special use the treatment of the bone infection osteomyelitis, it is also suitable for other nonhealing wounds.

In the study of insect secretions it is necessary to determine the presence of materials in minute insect organs. To accomplish this, ingenious apparatus was developed with which determination can be made of the presence of urease in the brain, heart, stomach, Malpighian tubules, and wing muscles of individual larvae and pupae of blowflies.

TICKS AFFECTING MAN

Extensive tests were made to determine the efficiency of controlling adult American dog ticks by spraying vegetation with nicotine sulfate. This method was fairly successful in some cases, since a 90-percent reduction was apparent after 48 hours.

By marking ticks found in nature and observing their movements from month to month, it was shown that they concentrate along roadways and paths frequented by man and dogs. This emphasizes the need for an effective method of destroying the adults where they are thus concentrated.

Studies on host relationships confirmed previous data to the effect that meadow mice were by far the most important hosts of the immature stages of ticks. Rabbits were shown to be minor hosts. An experiment to determine the effect of meadow-mouse control, begun 2 years ago, indicated that tick infestation on the controlled area was reduced even though some mice came into the area. Accordingly it was decided to carry out, in cooperation with the Fish and Wildlife Service, a further test on an isolated tract where mouse control could be kept more complete. Owing to the slow development of this tick definite results will not be available for 2 or 3 years.

TICKS AFFECTING ANIMALS

A number of organic compounds were tested against the brown winter tick (*Dermacentor nigrolineatus* Pack.) and the Gulf Coast tick and at least three have been shown to have tick-killing properties. Progress is being made on the development of a dressing, for use on the ears of livestock, that will retain the tick-killing value of these materials for a considerable period. The determination that a light petroleum oil, such as is used on human hair, is an effective and cheap material for the destruction of the brown winter tick is an important contribution to the control of these serious pests of horses and cattle.

HOUSEHOLD AND STORED-PRODUCT INSECTS

The frequent occurrence of clothes moth damage to garments stored in boxes supposedly tight enough to exclude these insects led to tests to determine the exact size of the crevice through which newly hatched larvae of the common webbing clothes moth can pass. It was demonstrated that these larvae can penetrate a crevice four one-thousandths of an inch in width, but that they cannot pass through one three one-thousandths of an inch in width.

Low concentrations of paradichlorobenzene vapor were found to cause a retardation, and finally a cessation, of larval feeding of the black carpet beetle. Even though the larvae stopped feeding for periods of 4 to 6 weeks, depending on the concentration of the fumigant, large proportions of them remained alive at the end of these periods and resumed normal feeding. This resumption of activity before death occurred, due to the dissipation of the paradichlorobenzene vapors, is an important consideration in the use of paradichlorobenzene in the control of carpet beetles.

INSECT IDENTIFICATION

A total of 60,485 identifications were made and were reported to the senders of the material. Of these about 73 percent were for the various research and regulatory units of this Bureau and for other Federal organizations. The remainder were for agencies of the various States and insular possessions, individuals in the United States, and foreign institutions and individuals. Nearly 35 percent of the determinations reported were incomplete or required qualification owing to the existing uncertainty concerning the limits of species and to the lack of knowledge of distinguishing characters in many groups. This indicates need for increased emphasis on research in insect classification. Assistance was rendered numerous outside workers in connection with problems involving insect taxonomy, nomenclature, morphology, species distribution, and host relationships, and 141 loans and exchanges of insect material, involving 13,698 specimens, were arranged. Ninety-six manuscripts were reviewed and criticized, the principal object of the review being the checking of all scientific names of insects contained.

The extensive reference collections have received the required care and in many groups there have been definite improvements in arrangement in accordance with increased knowledge of the classification. Approximately 78,000 specimens from routine sources were added to the reference collections during the year. In addition, a valuable collection of leafhoppers, comprising 75,000 specimens and

containing type material of nearly 1,300 species, was acquired through joint purchase by this Bureau and the National Museum.

In addition to the research involved in insect identification, definite advances were made on the large number of assigned problems relating to the classification of various insect groups. Thirty-two manuscripts were completed and submitted for publication, including various larger revisional studies. Among these are revisions of the bark beetle genera *Pseudohylesinus* and *Hylastes*, a monographic treatment of the Protura of North America, a study of ant parasites of the family Eucharidae, a revision of the grasshoppers of the genus *Orphulella*, a classification of the scale insects of the genus *Asterolecanium*, and a revision of the wasps comprising the genus *Trypoxylon*. Near completion at the end of the year were a number of other large and important papers, including a revision of the economically important fruitfly genus *Anastrepha*, a monographic study on the blowflies comprising the family Calliphoridae, a classification of the raspberry fruitworms of the genus *Byturus*, a revision of the numerous species of buprestid beetles comprising the tribe Chrysobothrini, a revision of the moths of the geometrid genus *Ellopia*, a type catalogue of the genera of bees of the world, a revision of the chalcid parasites of the genus *Monodontomerus*, a classification of the North American fleas, and a large detailed morphological study on the male genitalia of the insect order Hymenoptera. Substantial progress was also made on numerous other studies that are somewhat narrower in scope.

FOREIGN PARASITE INTRODUCTION

The foreign investigations upon the natural enemies of crop pests were continued throughout the year at the Yokohama, Japan, field station, but that at St. Cloud, France, was discontinued in October 1939 because of war conditions. Two members of the staff of this station were then assigned to work in South America, with headquarters at Montevideo, Uruguay. The new Parasite Receiving Station at Hoboken, N. J., was completed and occupied in June 1940 and the staff of the Moorestown, N. J., station has been assigned to it. Up-to-date facilities are now available for the quarantine of all types of shipments of foreign origin. All such shipments will be received there and any hyperparasites or living host material will be eliminated before the parasite stocks are transmitted to the various field stations of the Bureau for rearing and colonization.

PARASITES OF CEREAL AND FORAGE INSECTS

Contemplated importations of parasites of the European corn borer and the hessian fly from France during the fall of 1939 were prevented by the outbreak of the European war. A single shipment of *Triaspis thoracicus* (Curt.), a parasite of the vetch bruchid, was forwarded and yielded 8,849 adults, of which 5,210 were forwarded to field stations for rearing and colonization. Laboratory rearing at the receiving station provided an additional 7,318 adults for colonization later in the year.

During the last half of the year an extended survey was made of the white-fringed beetle in Chile. Localized infestations of sufficient extent to cause crop injury were found in several southern localities.

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This survey supplements the one made during the spring of 1939 in Argentina, Uruguay, and southern Brazil. These studies are yielding much information regarding the range and habits of the pest in its native habitat, from which tentative conclusions regarding its future spread in the United States, and the extent of its attack upon different crops, may be drawn. No natural enemies have yet been found.

PARASITES OF COTTON INSECTS

Activities on parasites of the pink bollworm were limited to the importation of an additional rearing stock of *Microbracon kirkpatricki* from Egypt and continued rearing work in Japan to build up a stock of *Chelonus pectinophorae* Cush. for shipment later in the year.

PARASITES OF FOREST INSECTS

In continuation of the cooperative activities of the Bureau with the Canadian Department of Agriculture upon the spruce sawfly in Europe, it was possible to make a survey covering Sweden, Finland, and Norway during July to September, 1939. This survey supplemented that made in northern Europe during the previous year. In Sweden and Finland it was found that parasite attack upon the sawfly larvae ranged up to 60 percent, and infestations of sufficient extent to permit of large-scale collecting activities were found in these countries. Sample collections of about 3,000 cocoons were made during the course of the survey and these were forwarded to the parasite laboratory of the Canadian Department of Agriculture for rearing with their own larger collections made in the same localities. Approximately 80,000 adult parasites, of 10 European species, were received from the Canadian Department of Agriculture for colonization in infested areas in the United States.

PARASITES OF FRUIT INSECTS

Importations of Japanese beetle parasites consisted only of 616 adults of the Chosen (Korean) strain of *Tiphia popilliavora* for use as a rearing stock to provide colonies for later release.

The principal studies on natural enemies of the oriental fruit moth in Japan and Chosen dealt with the determination of the alternate hosts of several of the more important species. *Inareolata molestae*, which increases rapidly during the season of release in the United States but has difficulty in passing the winter in satisfactory numbers, was found to have a considerable number of alternate hosts in Japan. Some of these are apparently much more suitable for hibernation than is the fruit moth. No parasites of this pest were imported during the year.

One of the new activities of the Yokohama station is the study and importation of parasites of *Pseudococcus comstocki*, a pest of Asiatic origin which is becoming a major pest of apple in the eastern part of the United States. In Japan this insect is not an important pest and is apparently controlled by natural enemies. Six species of parasites have been found, one of which already occurs in the United States. Shipments thus far made from Japan total approximately 166,000 larvae of 3 undescribed species of *Allotropa*, 1 species of *Anagyrus*, and 1 of *Leptomastix*.

PARASITES OF TRUCK CROP INSECTS

During the summer of 1939 a total of 9,500 puparia of *Meigenia mutabilis* (Fall.) (formerly referred to as *floralis* Meig.) and 17,825 host larvae containing this parasite were imported from France for use against the asparagus beetle. From this material 6,550 adult flies were reared and liberated in infested fields in New Jersey during the period from late June to August. Excellent establishment was secured, but overwintering conditions were apparently adverse, as none of the flies appeared in the field the following spring.

A consignment of 1,300 puparia of *Lydinolydella metallica* Towns., a parasite of the larvae of the Mexican bean beetle and other species of *Epilachna*, was forwarded from Brazil for test against the bean beetle.

The survey of the pea moth and its natural enemies in France was completed at the end of the 1939 season. Five species of parasites were found to attack it, although only two, *Ascogaster quadridentata* Wesm. and *Glypta haesitator* Grav., were of any importance. Field parasitization ranged up to 40 percent, with an average of less than 20 percent.

EFFECT OF CHEMICAL CONTROL METHODS ON POPULATION OF NATURAL ENEMIES

Activities under this project continued on the same basis as last year. The work on fungous diseases of scale insects in Florida was completed and the Orlando station closed. The staff was transferred to the Whittier, Calif., station to expand the work on the series of citrus pests under investigation there.

Results of the biological-control experiment on the codling moth in West Virginia, which is being conducted cooperatively with the Division of Fruit Insect Investigations and the West Virginia Agricultural Experiment Station, were not so favorable as in preceding years, owing mainly to a very light setting of fruit in the biological-control orchard as compared with that which received the standard spray treatment. The percentages of sound picked fruit were 53.4 and 71.7, respectively, for the two orchards. A predaceous thrips was much more abundant in the biological-control orchard and is a very effective predator upon the codling moth eggs.

Experiments on the citrus red mite in California showed that the infestations following treatment with oil-derris were higher than they were in untreated groves, and the predator populations were lower. Black scale populations increased more rapidly after spraying with oil than after fumigation, and parasitization was higher in the fumigated groves. Extended tests were made on the effect of various insecticides used against citrus pests upon the different stages of their natural enemies. Both oil sprays and cyanide fumigation were very destructive to the predaceous mite which preys upon the citrus red mite. Dinitro dust was exceptionally destructive to the immature stages of all red mite enemies. Both cyanide fumigation and oil sprays were slightly detrimental to the immature stages of parasites of the black scale, while cyanide killed a higher portion of the unemerged adults. Fumigation of the yellow scale parasitized by *Comperiella bifasciata* How. revealed that a dosage sufficient to kill practically all scales permitted the survival of large numbers

of the parasite if they are in the pupal stage. Advantage can be taken of this resistance of the parasites in timing field fumigation. The coccinellid beetle *Lindorus lophantae* (Blaisd.) is very susceptible to cyanide fumigation, whereas *Cryptolaemus montrouzieri* Muls. shows a low mortality at standard dosages. Tartar emetic sprays were found to be very injurious to adults of the parasite *Comperiella bifasciata*, while among the predaceous beetles it was distinctly harmful to *Lindorus lophantae* and *Coccidophilus citricola* Brethes, whereas *Cryptolaemus* is little affected by it, apparently because the beetles do not feed to any extent upon the spray deposit.

In the investigations of fungus diseases of scale insects, particularly the purple scale, in Florida, new methods were devised for sampling the population to determine the incidence of disease under different treatments and the effect of the disease on the host at different population levels. Final results established that the disease has little or no effect upon the scale population, that the scale build-up after spraying is due to a granular residue left upon the foliage after spraying rather than to destruction of the fungus, and that fungicidal sprays can be applied against citrus diseases without a resultant build-up of scales provided the material used does not leave a granular residue.

COOPERATIVE WORK WITH PUERTO RICO

Cooperation with the Puerto Rico Agricultural Experiment Station of the Office of Experiment Stations in the importation of natural enemies of crop pests has been continued and has been extended to the Experiment Station of the University of Puerto Rico. This Division has supplied directly, or has arranged through State agencies for the importation of, *Cryptochaetum iceryae* (Will.) for colonization against the cottony cushion scale and of four species of parasites of the black scale. Shipments from Puerto Rico to the United States comprised an additional stock of the Sao Paulo strain of the Amazon fly parasite of the sugarcane borer and a colony of *Coelophora inaequalis* (F.), a predator upon the sugarcane aphid.

COOPERATION WITH FOREIGN ORGANIZATIONS

In addition to the cooperative work upon spruce sawfly parasites with the Canadian Department of Agriculture, which has already been mentioned, this Division has arranged for the shipment of a colony of *Gambrus stokesii* Cam. to that organization for use against the codling moth and for a shipment of the oriental fruit moth parasite *Macrocentrus ancylivorus* to Japan. The staff of the Yokohama station cooperated with a representative of the Rehavoth, Palestine, Agricultural Research Station in locating natural enemies of *Pseudococcus comstocki* and in preparing colonies for shipment to Palestine. Assistance was also given in the forwarding of large-scale shipments of oriental fruit moth parasites from the United States to the Australian Council for Scientific and Industrial Research.

Through the courtesy of the Egyptian Ministry of Agriculture a further shipment of 600 cocoons of *Microbracon kirkpatricki*, an African parasite of the pink bollworm of cotton, was secured to provide a new stock for rearing purposes.

CONTROL INVESTIGATIONS

TESTING INSECTICIDES

During the year a new method for dispersing insecticides as aerosols, or in the form of smoke, was developed, which seemed to increase the effectiveness of various insecticides when dispersed in the air. The method consists in spraying liquid insecticides or solutions of insecticides on a hot surface (375° C.) so that the material is dispersed as a smoke in the air. Although still in the experimental stage, the method may prove to be a cheap and efficient way of controlling insects in closed spaces, such as army barracks. Rotenone-bearing insecticides applied in this way have proved effective against houseflies and mosquitoes, and an orthodichlorobenzene-naphthalene mixture is effective against cockroaches, bedbugs, houseflies, and mosquitoes, and is very inexpensive.

The cooperative work with the Division of Drug and Related Plants of the Bureau of Plant Industry on American-grown pyrethrum and rotenone-bearing plants was continued. Approximately 3,000 tests were made on 640 plant materials by the biological-assay method. The results indicate that American sources of these insecticides are promising, a finding that will be significant in case foreign sources are cut off.

The work on synthetic organic compounds has been directed largely toward extending tests of materials that had previously shown toxicity to insects. Field-laboratory methods were developed for determining the length of time the insecticide would remain effective on foliage under natural conditions, the plants being sprayed in the field and the leaves removed to the laboratory at various intervals for tests on the insecticide. In these tests one material retained its toxicity for about 10 days under practical conditions and three others showed promise. They produced little if any injury to the foliage of various truck crops to which they were applied. Another, phthalonitrile, was toxic to eight species of leaf-feeding larvae, but lost its toxicity after 4 to 6 days on the foliage, the residue apparently being lost by volatilization. Consequently, there should be no objection to the spray residue from this compound. Another material that had shown toxicity to leaf-feeding insects was also toxic to houseflies.

A fumigant was found that in laboratory tests was at least equal to carbon disulfide in toxicity to stored-grain pests. Approximately 5,000 tests were made, including the tests with the 126 compounds that were available for the first time. Of these new compounds about 12 showed possibilities of being useful insecticides.

Laboratory tests showed that insecticides ground very fine, to an average particle diameter of 1.1 microns, caused higher mortality in Mexican bean beetles and permitted less feeding than the coarser samples of the same insecticide with particles 12 to 22 microns in diameter.

FUMIGATION INVESTIGATIONS

Investigations on the fumigation of nursery stock with methyl bromide for the immature stages of the Japanese beetle were continued. It was shown that complete mortality could be obtained in soil masses as large as 12 inches in least diameter, and dosages and exposures were worked out for the commercial application of

this treatment at 50°, 54°, and 70° F., as well as at the previously authorized temperature of 63°. Treatment at any of these four temperatures, with a dosage and exposure that will destroy larvae of the beetle, makes unnecessary in most cases the delay and cost of heating the nursery stock to a prescribed temperature.

The use of methyl bromide in fumigation of produce for the adult Japanese beetle was extended to a number of commodities with excellent results. Improvements in the methods have reduced the cost of applying the treatment, and approximately 5,500 carloads have been treated since fumigation with methyl bromide was authorized. Well over a million pieces of nursery stock have been fumigated for Japanese beetle larvae since the authorization of the treatment in 1939.

Work on fumigation of nursery stock with methyl bromide for the white-fringed beetle has been continued, and 40,000 to 50,000 plants were treated by this method in New Orleans.

A method was developed for the fumigation of potting soil with methyl bromide for the white-fringed beetle at a cost of approximately 10 cents per cubic yard, as compared with $2 or $3 per cubic yard for steam sterilization, the method formerly employed. The cost of soil sterilization for the entire industry in New Orleans can thus be lowered by several thousand dollars per season.

Fumigation of sweetpotato plants and vine cuttings with methyl bromide, which had been tried experimentally last year, was tested on a commercial basis during the present season, and approximately 23 acres were planted with fumigated plants. The results indicate that this method of treatment, which is much less costly than fumigation of the seed sweetpotatoes, will destroy all stages of the weevil that may be present without injury to the plants.

Further advances were made in the study of the tolerance of dormant fruit stocks to methyl bromide fumigation required by several States under oriental fruit moth quarantines. The method is now in commercial use, and thousands of trees were fumigated and shipped from midwestern nurseries to the western fruit-growing States during the year.

Methyl bromide fumigation was applied to treatments of all infested shipments of nonfoliated dormant plant material entering this country under special permit and for the sterilization of certain types of foliated and evergreen plants. Considerable quantities of perishable food products were also fumigated with methyl bromide under quarantine regulations, 92,181 hampers of green lima beans, 5,578 boxes of pigeon peas, and 33,138 hampers of string beans being fumigated for the bean pod borer *Maruca testulalis* (Geyer). A method was developed for fumigating beans in the producing region, which resulted in a saving of $32,688 to shippers as compared with the cost of fumigating at terminal markets. The following products were imported into this country and successfully fumigated with methyl bromide: 23,600 cases of Cipollini bulbs, 9,356 packages of chestnuts, 2,432 boxes of grapes, and 606 boxes of peaches.

A total of approximately 2,500 varieties of nursery stock, ornamentals, and fruit stocks have been fumigated with methyl bromide. Of these about 5 percent were injured by the treatment. Methyl bromide has been tested in greenhouse fumigation for the control of red spiders, cyclamen mites, various mealybugs, whiteflies, aphids, and

other greenhouse pests. Rose, carnation, snapdragon, cyclamen, fern, and other greenhouse plants have been fumigated safely. In winter, dosages of 1 to 1¼ pounds per 1,000 cubic feet were effective in overnight exposures. The dosage can be reduced by one-half pound in the summer at temperatures around 70° F. A combination of nicotine and naphthalene showed promise as a fumigant for the greenhouse whitefly.

Investigations were continued on fumigation of vetch seed for the vetch bruchid, and schedules were developed for fumigation with chloropicrin and methyl bromide. A method of fumigation against the European corn borer was also worked out which makes possible simultaneous fumigation against this insect and the Japanese beetle on crops susceptible to infestation by both insects.

PHYSIOLOGY OF INSECTS

In the field of physiology of insects and the effects of poisons on the physiological processes, the studies of glycogen in southern armyworm blood cells and the effects of a number of poisons on the blood cells were completed. Administration of arsenicals or fluorides was followed by abnormal degenerative changes in the blood cells, whereas administration of rotenone, pyrethrum, phenothiazine, nicotine bentonite, nicotine peat, and nicotine did not cause marked changes in the cells. Among the cellular changes caused by the arsenicals and fluorides were glycogen decrease, change of form, agglutination, vacuolization, nuclear deformation, plastid formation, and loss of nucleus. It was also found that the buffer capacity of southern armyworm blood is great enough to maintain the blood at its normal pH value of about 6.6 in larvae subjected for 24 hours to air saturated with nicotine.

The role played by the blood cells and nephrocytes of the cockroach in maintaining the insect's resistance to poisoning by sodium arsenite and nicotine was investigated. The results indicate that functional blockage of the blood cells with Chinese ink caused a decrease in the resistance of the roach to nicotine and, particularly, to sodium arsenite.

APPLICATION OF INSECTICIDES

Investigations to develop more effective methods of applying insecticides, particularly from the upper air, were continued. In cooperation with the Connecticut Agricultural Experiment Station, 461 acres of woodland infested with the gypsy moth were treated with air-blended lead arsenate and fish oil distributed by an autogiro at the rate of 30 pounds per acre. The acreage covered was in hilly, heavily forested terrain and comprised the largest area of this nature yet treated for the gypsy moth by means of rotating-wing aircraft. The operations demonstrated the practicability of treating woodland in this manner and disclosed the possibility of replacing several ground spray units with one aircraft. Available figures indicate that utilization of aircraft in such a replacement could reduce by one-half or more the cost of spraying similar or rougher areas. While final observations concerning the effect of the treatment on the gypsy moth are not yet available, preliminary results appear to be excellent. Since in similar work conducted during 1939 a dosage of 20 pounds of lead arsenate per acre gave 92-percent control, and a 40-pound dosage resulted in

the extermination of the insect, the application of the insecticide this year with improved equipment at the 30-pound dosage should be entirely satisfactory.

INSECTICIDE INVESTIGATIONS

Research to develop new and more effective insectides was actively prosecuted, and the results were made available to the public by means of 39 scientific publications, comprising 2 department circulars, 3 articles in the Bureau's E series, and 34 articles in technical and trade journals. Twelve patents were issued to members of the Division, and the monthly review of United States patents relating to pest control was issued regularly and distributed to a large number of foreign and American entomologists.

INSECTICIDAL PLANTS (TOBACCO, DERRIS, PYRETHRUM, ETC.), AND THEIR CONSTITUENTS

Numerous species of *Nicotiana*, the genus of plants to which tobacco belongs, and hybrids produced by crossing them, were examined to determine how much nicotine they contain, whether other alkaloids of insecticidal value are present, and what relation the alkaloid of the hybrids bears to that of the parents. Further attention was also devoted to the solid compounds of nicotine, one of which, nicotine bentonite, is the most promising organic substitute for lead arsenate for the control of codling moth larvae. A study was made of different bentonites on the American market, and a procedure was developed for making a nicotine bentonite that does not build up such an unsightly deposit on fruit and foliage as does the tank-mix product. The chemistry of bentonite in relation to base exchange was investigated to obtain fundamental knowledge helpful in the study of nicotine bentonite. An improved method for the separation of nicotine from anabasine, nornicotine, and related alkaloids was worked out. New analytical procedures for the quick and accurate determination of minute quantities of nicotine, such as would occur in spray residues of nicotine bentonite, were perfected, and nornicotine was found to be the predominating alkaloid in a specimen of Maryland tobacco.

The importation of the roots of derris from the East Indies and of cube and timbo (*Lonchocarpus*) from South America has increased greatly. First brought in less than 10 years ago, in 1939 there were imported 2,335,048 pounds of crude derris root, 1,907,194 pounds of crude cube and timbo roots, and 896,640 pounds of powdered roots. These roots contain rotenone and rotenoids (deguelin and related compounds), which are among the most potent insecticides known. Extracts of these roots are used in fly sprays and greenhouse sprays, and the powdered roots mixed with talc or other diluents have a wide use in combating the pea aphid, the pea weevil, the Mexican bean beetle, and cabbage caterpillars.

Accomplishments during the year include the finding of a minute quantity of alkaloidal material in derris, cube, and timbo roots, which, however, proved nontoxic to mosquito larvae. An improved method of dispersing the insecticidal constituents of derris, pyrethrum, and other plant material was developed in cooperation with entomologists of the Division of Control Investigations. It consists in burning the powdered material under such conditions that a dense smoke is formed, or in spraying an extract in a suitable organic solvent upon a heated

surface such as an electric hot plate. When tested against the housefly the smoke from burning derris powder was more than 10 times as toxic as that from pyrethrum burned in the same way.

Various colorimetric methods that have been proposed for evaluating rotenone products were compared, and a method was developed for determining deguelin in derris and cube. Heretofore no method of estimating this valuable insecticide was known. One extraction with water removed from 24 to 41 percent of the active material from derris, cube, and timbo and successive extractions removed more. When preserved against fermentation, these suspensions of the active principles are stable. The only domestic source of rotenone is *Tephrosia virginiana* (L.) Pers., known as devil's-shoestrings. Because of its potential importance as an agricultural crop and as a substitute for the foreign-produced derris and cube, the nature of its active ingredients was studied very thoroughly. Deguelin was found in it for the first time, and several other definite crystalline compounds were isolated although not definitely identified.

The toxicity to the housefly of several compounds of the rotenone series was determined, in cooperation with the Division of Control Investigations. The following concentrations dissolved in kerosene-cyclohexanone (milligrams per cubic centimeter) were found to be necessary to give 50-percent mortality: Rotenone 0.30, levodihydrorotenone 0.38, levodihydrodeguelin 0.51, levo-β-dihydrorotenone 0.52, levodeguelin concentrate 0.57, racemic deguelin 0.59, and racemic dihydrodeguelin 0.83. When dissolved in acetone the two racemic compounds were much less toxic than when dissolved in kerosene-cyclohexanone, but the other compounds were about equally toxic in the two solvents.

Because of the importance that these rotenone plants have attained, efforts were continued to find other plant materials with insecticidal value. Methods were developed for concentrating the active principle of the Amur cork tree (*Phellodendron amurense* Rupr.), and its chemical nature is being studied. Several other plants reputed to have insecticidal effect were examined in a preliminary fashion. They included thunder-god vine (*Tripterygium wilfordii* Hook, f.), Kentucky coffeetree (*Gymnocladus dioica* (L.) Koch), sweet basil (*Ocimum basilicum* L.), creosotebush (*Larrea divaricata* Cav.), and *Stillingia dentata* (Torr.) Britt. and Rusby. Only the thunder-god vine yielded results sufficiently encouraging to warrant more work.

The United States imports annually from 15 to 20 million pounds of pyrethrum flowers, largely from Japan. The two active principles, pyrethrin I and pyrethrin II, find wide use in household fly sprays, cattle sprays, and dust insecticides for application to celery, cabbage, cranberry, and many other crops. Pyrethrum is a valuable insecticide because it leaves no poisonous residue on foodstuffs and because it acts quickly. No synthetic material has been found that rivals pyrethrum in speed of action. A study of the structure of pyrethrins I and II has been prosecuted in the hope that it would be possible to synthesize compounds of less complexity which, because they retained part of the structure of the pyrethrins, also shared their remarkable insecticidal activity. This work has definitely proved that there is an allene structure in both pyrethrins, and with this point established it will be possible to proceed to the synthesis of analogous

compounds. There seems to be little possibility of synthesizing the pyrethrins themselves.

Certain species of *Helenium*, including the sneezeweed of the Southern States, were further studied, and a new compound called tenulin was isolated. The presence of a very bitter material analogous to the quassin of quassia wood leads to the hope that *Helenium* may be used in place of quassia, about 1,000,000 pounds of which are imported annually.

Geraniol, a major ingredient of Java citronella oil (from the grass *Cymbopogon nardus* (L.) Rendle), is in wide use for luring Japanese beetles to traps. The commercial materials that are offered in response to purchase orders may meet the specifications drawn up for them, and yet differ markedly in their attractiveness. The composition of one of the most attractive samples was studied and the identified compounds were prepared in pure form and supplied, alone or in various mixtures, to cooperating entomologists for further study. There are indications that the specifications for geraniol for Japanese beetle traps can be improved.

DEVELOPMENT OF SYNTHETIC ORGANIC INSECTICIDES

In the attempt to displace objectionable arsenic from its commanding position among insecticides, some of the many thousands of organic compounds now available were studied. Even though there is little possibility of synthesizing rotenone or the pyrethrins, which are already established as important insecticides, it is reasonable to believe that other equally valuable compounds may be discovered. Several hundred compounds were obtained or made, and submitted to cooperating entomologists for preliminary testing. Those showing promise were made in larger quantities sufficient, in some cases, for small field tests. Those few compounds that showed sufficient promise were studied thoroughly with the idea of finding how to adapt them to actual use. For example, phenothiazine, when prepared in very fine form, was found to have superior adherency and toxicity. The search for adhesives for this compound was continued, and improvements in its fungicidal effect were brought about. Xanthone, having become commercially available, was included in various spray schedules for testing, as was phenazine, which likewise can now be purchased.

The toxicity of several hundred organic compounds to codling moth larvae was studied in the laboratory jointly with the Division of Fruit Insect Investigations. Only 17 compounds gave 50 percent or less of wormy apple plugs.

SPRAY RESIDUES AND THEIR REMOVAL

The study of insecticide deposits continued to be the principal means of comparing spray schedules, methods of application, persistence through the season, and other variables which may be expected to influence the over-all effectiveness of an insecticide. Residues of lead arsenate, nicotine, and phenothiazine were studied before and after every spraying, and in every plot in which those compounds were used at Yakima, Wash., and Vincennes, Ind., where field tests for the development of insecticides for control of codling moth are conducted. At Whittier, Calif., similar studies of

sulfur residues were conducted to check on the use of this element in the control of the citrus thrips. At the same laboratory residues of tartar emetic, used against the citrus thrips, were investigated, and a method for determining the antimony content was developed. Because of the importance of copper fungicides, methods for determining copper spray residues were studied.

Experiments concerning removal of residues from cryolite sprays, conducted at Yakima, Wash., showed that dual washers were required to remove the rather heavy residues of fluorine.

New methods of removing residues preliminary to chemical determination were developed, and the work thereby expedited. Also, many of the residue studies were so arranged that the expected natural variation could be estimated and data collected that will permit of more critical judgment when the mean results are compared with one another.

Work was done on the removal of nicotine spray residue from apples, in cooperation with the Bureau of Plant Industry at Yakima, Wash. Nicotine residues of 0.01 grain per pound resulting from the application of six cover sprays of nicotine bentonite were entirely removed in a dual-process machine using sodium silicate at 110° F. in one compartment and hydrochloric acid at 100° in another. Each of these solutions used alone is effective in reducing the nicotine residue to 0.001 to 0.003 grain per pound.

DEVELOPMENT OF INORGANIC INSECTICIDES

A phase-rule study of the system sodium hydoxide-arsenious acid-water was conducted to obtain information concerning sodium arsenite, which is used extensively in controlling the Mormon cricket. The data include solubility figures for all possible combinations of the three components, and indicate all the definite compounds that exist at the chosen temperature. A new compound was discovered.

White arsenic, despite its high arsenic content, is not sufficiently poisonous to the Mormon cricket to warrant its use. It was surmised that its low toxicity might be due to a low solubility in water; a study was therefore made of the solubility in distilled water, in water adjusted to definite hydrogen-ion concentrations, and in solutions of colloidal materials such as glue and gum arabic. The solubility was found to be markedly affected by the conditions mentioned, and this knowledge may perhaps lead to improvement in the use of the compound. All three of the well-known forms were included in the solubility experiments, and it was found that the amorphous variety was more rapidly soluble than the others. Its use as an insecticide may be indicated.

Cryolite has proved to be toxic to the European corn borer, and its commercial use might be feasible except for the fact that at times it severely injures the leaves of the corn plant. Because this injury is thought to be due to the solubility of the material, a study was made of ways of reducing the solubility by admixture with substances that contain common ions that will buffer the mixture to an optimum hydrogen-ion concentration, or that will precipitate the fluorine that dissolves. Eighteen samples of cryolite, comprising natural and both domestic and imported synthetic material, were examined. This investigation is being continued.

The particle size of 16 samples of commercial lead arsenate, determined by sedimentation analysis, was found to be mostly below a diameter of 2 microns, with from 10 to 60 percent of material below a diameter of 1 micron. The loose bulking value (cubic inches per pound) of a sample of lead arsenate does not give an indication of the particle size. In cooperation with the Division of Control Investigations it was shown that paris green particles with an average diameter of 1.1 microns caused higher mortalities of the Mexican bean beetle and permitted less feeding when applied to bean foliage, either as a spray or as a dust, than did particles of 12 microns, which were intermediate, and of 22 microns, which caused the lowest mortality and permitted the greatest amount of feeding.

Heating calcium arsenate sufficiently to make it relatively safe to bean foliage likewise made it nontoxic to silkworm larvae. In general, ignition decreased the percentage of soluble arsenic present. However, there does not appear to be any appreciable correlation between the percentage of soluble arsenic as determined by the method of the Association of Official Agricultural Chemists and the toxicity to insects or plants.

FUMIGANTS FOR CONTROL OF INSECT PESTS

Chemical studies on the fumigation of stored grain and cereal products for control of the insects infesting them were resumed at the Manhattan, Kans., laboratory. Investigations were begun on the composition of commercial fumigants offered for this purpose, of the adsorption of hydrocyanic acid by flour fumigated with it, of the effect of the moisture content of wheat on the results obtained with certain fumigants, and of the minimum lethal concentrations of various fumigants.

At the Whittier, Calif., laboratory attention continued to be devoted to the control of the so-called resistant strain of the California red scale with hydrocyanic acid and other fumigants. The chemical work consisted in the establishment and maintenance of known concentrations of the fumigant under conditions that would eliminate the influence of protective stupefaction brought on by accidental exposure to sublethal concentrations. Similar work was conducted with methyl bromide, to see if this recently developed and versatile fumigant might find another application here.

Work on dispersing insecticides in the form of smokes (see the discussion of derris) was extended to ortho- and paradichlorobenzene, naphthalene, and tetrahydronaphthalene. A high concentration of these materials can be built up by dropping solutions of them in safrole on a heated metallic surface.

Studies on chlorine gas as a seed disinfectant, done in cooperation with the Bureau of Plant Industry, showed that, to obtain satisfactory killing of smut spores borne on the surface of the seed without causing pronounced seed injury, the gas concentration should not be less than 3 or greater than 9 percent, the time of exposure from 1 to 2 hours, and the volume of pure chlorine gas not less than 20 percent or more than 40 percent of the net volume of the seed being treated. In experiments with weevils it was found that some active adult grain weevils survived after exposure to concentrations of 10, 20, and 50 percent of chlorine gas for 60, 20, and 10 minutes, respectively.

Two bibliographies on cyanide compounds used as insecticides were issued in mimeographed form.

ACCESSORY MATERIALS FOR USE WITH INSECTICIDES

The study of wetting agents was continued. Measurements of surface tension, and of the tension existing between solutions of the agents and a standard mineral oil, were made for over 200 proprietary products as a means of surveying their relative value as surface-tension depressants, this depressing action being the most important characteristic of a substance to be used as a spreader with insecticides. A new method of getting further evidence on this characteristic was developed, which consisted in titrating a solution of a given wetting agent with distilled water or artificial hard water until the surface tension was reduced to a pre-selected figure.

Because phenothiazine continues to show promise as an insecticide against the codling moth, the effort to find an adhesive capable of retaining it upon apples was resumed. Evidence was obtained of some favorable action by several proprietary products, by freshly precipitated aluminum hydroxide, by aluminum silicate, and by wet grinding of certain mixtures.

Various oxides of iron were studied as possible correctives for the injury to crops grown in soil treated with white arsenic, in an attempt to adapt that insecticide, which is cheaper than lead arsenate, to the control of Japanese beetle grubs. No special value could be demonstrated.

The study of powdered diluents for use with sodium arsenite in controlling the Mormon cricket was continued, special attention being paid to a commercial product consisting of pyrophyllite from which it was possible to obtain a considerable fraction of coarse material, which previous studies indicated to be desirable for use with the very coarse sodium arsenite being employed.

The wetting and spreading properties of mixtures of sodium carbonate with n-caproic, n-caprylic, n-capric, lauric, myristic, and palmitic acids were investigated. For aqueous mixtures of sodium carbonate with 1.0 percent of fatty acid, the surface tension, interfacial tension against mineral oil, and spreading coefficient, when plotted as functions of the alkali-fatty acid-mole ratio, give curves that are similar in form with few exceptions. The relative positions of the curves correspond approximately with the order of increasing molecular weight of the fatty acid. The characteristics of the carbonate mixtures are similar to those of the corresponding hydroxide mixtures, with some differences which are apparently accounted for by the diacidic nature of the carbonate. The oleate mixtures have exceptional properties which help to explain their excellence as detergents.

In a study of inorganic salts as adjuvants for increasing wetting power, tests were made with a sulfonated ester of a dicarboxylic acid. Addition of chlorides of calcium, magnesium, or sodium to solutions of this wetting agent produced significant increases in wetting power, as measured by surface tension or by spreading coefficient on mineral oil. The improvement was so substantial as to indicate that this effect may be of practical importance in the formulation and use of these materials.

TOXICITY OF NEW INSECTICIDAL COMPOUNDS TO GOLDFISH

A study of the influence of temperature in the method used for determining the toxicity of insecticidal materials to goldfish was finished during the year. The study was conducted with rotenone and phenol, because these 2 compounds have been used often as standards of comparison with other compounds. Five temperatures between 7° and 27° C. were chosen. The minimal product of concentration and time, upon which all the conclusions in this work are based, has been estimated with a standard error of 2 to 4 percent for phenol and 5 to 14 percent for rotenone. Despite the fact that the minimal product for rotenone is some 500 times that for phenol, the relationship between the two remains practically constant. The toxicity of either compound is an experimental function of the temperature; a 10° rise in temperature results, on an average for both compounds, in a 2.7-fold increase in toxicity.

Of the 3 mononitrophenols the ortho compound is the least toxic to goldfish. The meta compound is nearly twice as toxic and the para compound about 5 times as toxic as the ortho compound. Rotenone is 250 times as toxic as o-nitrophenol. The relative toxicity of the chlorophenols as compared with phenol was found to be: Ortho, 1.15; meta, 1.51; and para, 1.89.

ANALYTICAL INVESTIGATIONS

The analytical work of the Division embraced, as usual, the analysis of experimental samples being tested by other divisions of the Bureau. Nearly 700 such samples were received. In addition, about 750 soil samples from nurseries were analyzed for the Division of Japanese Beetle Control to see whether they should be retreated with lead arsenate to bring them up to the minimum quarantine requirements.

The Division took part as usual in the activities of the Association of Official Agricultural Chemists, conducting for them the collaborative testing of a method for minute amounts of arsenic developed in the Division, and of methods for the preliminary digestion of such organic matter, notably tobacco and shrimp, that has proved difficult to handle by the ordinary sulfuric and nitric acid digestion. Collaborative testing of a method for determining methoxyl in lignin and rotenone was done by the member of the Division who is the association's referee on microchemical methods.

Methods for determining micro amounts of nicotine were perfected, one of which depends on measurement of the turbidity produced with phosphotungstic acid. The influence of various impurities on the colorimetric test involving cyanogen bromide and β-naphthylamine was studied, and the method adapted to the study of the nicotine content of single green leaves of growing tobacco, which will be of assistance in tobacco-breeding experiments.

A method was developed for determining the residues of antimony left on citrus trees treated with tartar emetic for control of the citrus thrips. Tentative procedures were also developed for residues of copper resulting from the use of copper-containing fungicides in codling moth control. Efforts to find a micro method suitable for determining residues of xanthone, a new organic insecticide, were unsuccessful.

Improvements were made in the preliminary handling of apples preparatory to the determination of residues. A machine capable of tumbling the sample in a chemical solution was developed, and solutions capable of satisfactorily recovering lead arsenate, nicotine, and phenothiazine were found. These developments will permit of handling a greater number of samples than could be analyzed before.

Improvements were made in the machine previously developed in the Division for measuring the average particle diameter of powdered insecticides and diluents. Proof was accumulated that the reproducibility of results from one machine to another, and from one operator to another, is satisfactory.

The methods for analyzing geraniol were restudied in an effort to make them more discriminating. The determination of boiling range was improved, and specifications for its use were drawn up. The method heretofore used for aldehyde content was found to be inferior to another suggested procedure, and steps were taken to adopt the latter.

A procedure for quickly and accurately analyzing large numbers of soil samples for arsenic present in amounts ranging from a trace to 0.06 percent was completed. Soil treated with lead arsenate for the control of immature larvae of the Japanese beetle is analyzed by this method.

TRANSIT INSPECTION

Inspectors of the Bureau were stationed at 20 transportation centers for the inspection of shipments moving interstate via parcel post, express, and freight. During the year 1,383,623 shipments were examined to determine their compliance with regulations of Federal domestic plant quarantines, and more than 1,000,000 freight waybills were examined to determine the status of shipments consigned thereunder. As a result of this inspection, 2,967 shipments were intercepted moving interstate in apparent violation of 8 Federal domestic plant quarantines and 139 shipments moving in apparent violation of intrastate quarantines relating to pests on account of which Federal quarantines have been established. Of these shipments, 1,047 were of such a nature that it was possible to inspect them for insects or plant diseases and allow them to proceed to their destination. Nearly 2,000 shipments moving interstate in apparent violation of State pest-control laws or regulations were noted by transit inspectors in the course of regular activities and reported to the States concerned. Of this number 40 were moving in apparent violation of the standard State quarantines relating to the peach-mosaic disease. Inspection on a permanent basis was started at Buffalo, N. Y., during the year and discontinued at Springfield, Mass. During the spring shipping season temporary inspection was conducted at Birmingham, Ala., Dallas, Tex., and Memphis, Tenn. In December the inspection forces at Boston, New York, and Philadelphia were increased by the assignment of additional inspectors to assist in the inspection of the seasonal movement of plant material from the gypsy moth regulated area.

Cooperation was extended by affected States and by other projects of the Bureau in the assignment of inspectors to assist in the work, particularly during the shipping seasons.

Data pertaining to shipments intercepted at transit inspection points are given in table 11.

TABLE 11.—*Shipments of nursery stock and other articles intercepted in violation of Federal domestic plant quarantines at transit inspection points, fiscal year 1940*

Station	Shipments intercepted in apparent violation of quarantines relating to—								
	Black stem rust	Gypsy moth and brown-tail moth	Japanese beetle	Pink bollworm	White-pine blister rust	Mexican fruit-fly	Dutch elm disease	White-fringed beetle	Total
Atlanta		1	49	3		27		7	87
Birmingham			11	1				7	19
Boston		366	132		3				501
Buffalo	1	7	47		10	2			67
Chicago	2	13	122	5	10	3		3	158
Cincinnati		2	54	6	1	14		1	78
Dallas			1	2		16		3	22
Detroit		19	18						37
Indianapolis		1	3			4			8
Jacksonville		5	117	1		1		2	126
Kansas City		3	31	1		17		1	53
Memphis			5					14	19
New York		415	512		13		4	3	947
Omaha		7	63	2	1	2			75
Philadelphia		21	145	1	1	2			170
Pittsburgh	2	19	290		7	6			324
St. Louis		1	37	1		94			133
St. Paul	2		19		10	12			43
Springfield, Mass		63	19						82
Washington, D. C		4	2						6
State of California		5	58	5	16			1	[1] 85
Total	7	952	1,735	28	72	200	4	42	[2] 3,040

[1] Interceptions reported by cooperating State inspectors at several inspection points.
[2] The total number of violations represents 2,967 shipments, 69 of which were in violation of 2 quarantines, and 2 in violation of 3 quarantines.

TERMINAL INSPECTION OF MAIL SHIPMENTS

The State of Arizona made arrangements during the year, through Federal channels, for the turning back of parcel-post shipments found to be in violation of certain plant quarantines of that State. Other States which have availed themselves of the provisions of the terminal inspection procedure for the enforcement of plant-quarantine regulations are Arkansas, California, Florida, Mississippi, Montana, and Oregon.

Arizona, California, Florida, Idaho, Louisiana, Mississippi, Montana, Oklahoma, Oregon, and District of Columbia, Hawaii, and Puerto Rico maintain terminal inspection of designated types of plants and plant products under the procedure which provides for the turning back or disinfection of shipments found to be infected.

CONVICTIONS AND PENALTIES IMPOSED FOR VIOLATIONS OF THE PLANT QUARANTINE ACT

The number of convictions and penalties imposed for violations of the Plant Quarantine Act, aside from those dealing with Mexican plants and plant products, reported to the Bureau, was the lowest for any year since 1918, the first year that a record of them was made in the annual report. Only one such violation was reported, a violation of the Japanese beetle quarantine, which resulted in a fine of $1.

With regard to quarantines affecting Mexican plants and plant products, fines aggregating $492.70 were imposed by customs officials on the Mexican border against 463 persons caught attempting to smuggle in prohibited plants and plant products from Mexico. This compares with $401.25 assessed against 379 persons for similar offenses last year.

FOREIGN PLANT QUARANTINES

The Division of Foreign Plant Quarantines is engaged in the enforcement of quarantines and regulatory orders of the Department prohibiting or restricting the entry from foreign countries, or the movement from Puerto Rico and Hawaii to the mainland of the United States, of various plants and plant products, and restricting the movement of nursery stock into and out of the District of Columbia. In addition, this Division is responsible for the maintenance of a service to inspect and certify plants and plant products to meet the sanitary requirements of foreign countries and for the enforcement of the provisions of the Insect Pest Act of 1905.

Plant-quarantine inspectors and collaborators are stationed at the more important ports of entry and at certain interior ports where foreign mail is distributed. They work in close cooperation with employees of the Treasury and Post Office Departments.

MARITIME-PORT INSPECTION

SHIP INSPECTION

Ships from foreign countries and also those from Hawaii and Puerto Rico and the coastwise ships which pass through the Panama Canal are inspected promptly on arrival for the presence of prohibited and restricted plant material. This inspection involves the examination of ships' stores and quarters, passengers' and crews' baggage, and cargo.

The inspection at ports in California, Florida, and Hawaii and at certain ports in Puerto Rico has been performed by State and Territorial officials serving as collaborators of the Bureau.

A record by ports of the ship inspection appears in table 12.

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TABLE 12.—*Number of ships inspected, fiscal year 1940*

Port	From foreign ports												From Hawaii						From Puerto Rico						From United States ports via Panama Canal		
	Direct			Via United States ports			Via Hawaii			Via Puerto Rico			Direct			Via United States ports			Direct			Via United States ports					
	Arrived	Inspected	With prohibited material	Arrived	Inspected	With prohibited material	Arrived	Inspected	With prohibited material	Arrived	Inspected	With prohibited material	Arrived	Inspected	With prohibited material	Arrived	Inspected	With prohibited material	Arrived	Inspected	With prohibited material	Arrived	Inspected	With prohibited material	Arrived	Inspected	With prohibited material
Baltimore	772	772	358	1,008	844	435	----	----	----	1	1	0	1	0	0	50	2	0	20	20	2	41	40	2	274	102	1
Blaine [1]	48	48	21	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Boston	1,105	1,102	502	405	398	52	12	12	5	2	2	2	----	----	----	20	20	0	23	23	4	2	2	0	221	220	0
Brownsville	6	6	4	16	16	7	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	6	6	0
Buffalo	8	8	6	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Charleston [2]	296	274	91	118	116	37	----	----	----	----	----	----	----	----	----	----	----	----	4	3	0	31	31	3	15	15	0
Chicago	25	25	14	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Detroit	16	16	11	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Eureka [3]	4	4	1	4	4	1	1	1	0	----	----	----	2	2	0	5	5	0	----	----	----	----	----	----	----	----	----
Galveston	379	375	169	438	434	219	----	----	----	1	1	1	----	----	----	3	3	0	9	9	1	6	6	0	10	10	0
Gulfport [4]	13	13	12	5	4	3	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Honolulu [3]	223	223	77	9	9	0	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1	1	0	130	130	0
Houston	406	403	265	515	486	237	----	----	----	----	----	----	----	----	----	2	2	0	7	7	0	3	3	0	30	30	0
Jacksonville [3]	306	306	83	70	66	13	----	----	----	1	1	1	----	----	----	----	----	----	42	42	3	1	1	0	6	6	0
Key West [3]	144	131	47	7	7	0	----	----	----	----	----	----	----	----	----	----	----	----	1	1	1	----	----	----	----	----	----
Miami [3]	1,381	1,380	345	20	20	11	----	----	----	----	----	----	----	----	----	----	----	----	6	6	0	----	----	----	9	9	0
Mobile	403	403	152	287	251	105	----	----	----	----	----	----	----	----	----	3	3	0	34	34	4	32	32	3	35	33	0
New Orleans	1,205	1,205	605	543	541	275	3	3	2	----	----	----	5	5	2	15	15	1	12	12	2	52	50	2	46	45	1
Newport News	138	137	97	433	425	160	----	----	----	----	----	----	1	1	1	----	----	----	2	2	0	4	4	0	18	18	0
New York	3,700	3,600	2,090	1,019	744	397	----	----	----	75	75	59	18	18	1	51	44	1	134	134	32	10	8	1	376	243	3
Norfolk	533	533	355	709	705	283	----	----	----	2	2	0	----	----	----	----	----	----	13	13	2	34	34	0	89	89	0
Pensacola [3]	54	54	31	110	110	37	----	----	----	----	----	----	----	----	----	----	----	----	2	2	0	----	----	----	1	1	0
Philadelphia	893	892	390	1,073	584	366	2	1	1	2	2	1	3	3	2	56	13	0	51	51	18	4	2	0	371	62	1
Port Arthur	308	308	242	333	333	148	----	----	----	1	1	0	----	----	----	1	1	0	15	15	0	7	7	0	17	17	0
Portland, Oreg	103	103	73	275	195	82	4	4	4	----	----	----	4	4	2	22	14	0	----	----	----	----	----	----	449	56	1
Port San Luis [3]	30	30	26	----	----	----	1	1	0	----	----	----	7	7	0	----	----	----	----	----	----	----	----	----	----	----	----
Puerto Rico (all ports)	841	839	230	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	12	12	6
San Diego [3]	1,109	1,108	63	14	14	1	----	----	----	----	----	----	44	44	3	3	3	0	----	----	----	----	----	----	112	111	5
San Francisco [3]	335	335	204	628	626	252	111	110	66	----	----	----	216	216	48	58	57	11	----	----	----	----	----	----	543	542	11
San Pedro [3]	1,496	1,496	763	412	410	146	77	77	61	1	1	0	142	142	36	71	71	12	----	----	----	1	1	0	738	735	82

Savannah [5]	134	134	81	221	221	93	----	----	----	----	----	----	----	----	----	4	4	0	6	6	0	34	33	2	1	8	18	2	
Seattle	1,274	1,238	250	293	282	126	----	----	----	----	----	----	9	9	5	1	1	0	----	----	----	----	----	----	25	3	0	0	
Tampa [3]	267	267	56	240	188	81	----	----	----	----	----	----	----	----	----	----	----	----	28	28	5	13	0	0	2	1	6	3	
Ventura [3]	1	1	0	----	----	----	----	----	----	----	----	----	5	5	0	----	----	----	----	----	----	----	----	----	----	----	----	----	
West Palm Beach	172	172	8	11	11	4	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	
Total	18,128	17,941	7,722	9,216	8,044	3,571	211	209	139	86	86	64	457	456	100	365	258	25	409	408	74	276	255	13	3,80	0 2,	516	116	

[1] Includes ships arriving at Bellingham and Anacortes, Wash.
[2] Includes Georgetown, S. C., and Wilmington, N. C.
[3] Collaborators stationed at these ports.
[4] Work handled by inspector at Mobile.
[5] Includes Brunswick.

NOTE.—Foreign-ship arrivals do not in all cases agree with customs figures. Ships which put in for bunkers may not be counted by customs. Ships entered at certain small subports and counted by customs are not included in this report.

CARGO INSPECTION

All importations of plants and plant products subject to plant-quarantine restrictions are inspected at the port of entry or at the port of first arrival. A summary of such importations grouped under four general subdivisions appears in table 13.

TABLE 13.—*Summary of importations of plants and plant products inspected, fiscal year 1940*

Port	Fruits and vegetables			Nursery stock and seeds			Bagging, cotton, cotton products			Bagasse, broomcorn, corn, rice, fiber, etc.		
	Lots	Containers	Additional quantities	Lots	Containers	Additional quantities	Lots	Bales	Additional quantities	Lots	Bushels	Additional quantities
		Number			*Number*			*Number*			*Number*	
Baltimore	183	8	4,221,808 bunches	130	1,606	2,000 pounds	10	323	1,616,250 pounds	4	4,517	
Baltimore, for export	4	658		1	10							
Blaine	13	103	41,919 bunches	137	12,297	1 truckload, 215 pounds						
Boston	292	36,944	4,561,503 bunches	148	2,933	196 units, 798 pounds	780	102,971	65,219 containers	4	2,500	50 containers.
Boston, for export	36	16,105		63	173		77	19,145	2 containers	1		324 containers.
Brownsville	549	60,560	38,934 bunches, 90,433 pounds.	5	1	65 units	126	9,296	9,298,369 pounds, 50 containers.	35	218	1,588 pounds, 12 containers.
Buffalo	2	997		30	427	1,313 units, 1,074 pounds	36	716	3 containers			
Calexico	151	2,060	48,579 pounds	2		80 units	401	42,159	10,893,700 pounds, 26 containers.	1	26	
Charleston	198	113	1,973,685 bunches									
Chicago	5	4,273		5	38	206 pounds						
Del Rio	8	10	6 bunches									
Detroit	8	3,029		203	1,026	938 units	110	2,716		5	13	9 containers.
Douglas	15	42	224 pounds									
Eagle Pass	978	10,194	4,331 bunches, 5 units, 129,771 pounds.	1		12 pounds				19		159 dozen.
El Paso	2,832	54,332	1,798,902 pounds, 1,243,234 bunches.				33	205	1,110,756 pounds, 15 containers, 8 gallons.	12	302	
El Paso, for export										4	74	
Galveston	177	1,908	3,036,273 bunches				18	3,718				
Hidalgo	444	14,057	63,457 pounds, 36 units, 630 bunches.	11		28 pounds, 15 units	2		220 pounds	1	2	
Honolulu [1]	561	3,579	28 pounds	69	225	32 pounds	2	20	15,700 pounds	49		274 containers.
Honolulu, for export	4	29					2		4 containers	2		22 containers.
Houston	56	18,889	19,601 pounds	2	27		65	17,305				
Jacksonville [1]	186	12,305	2,406,847 bunches, 60 pounds.									
Key West [1]	302	2,658	2,440 bunches									
Laredo	3,339	202,091	2,261,488 bunches, 7 units, 5,126,429 pounds.	106	12	73 pounds, 16,324 units	17		1,661,054 pounds			
Mercedes										2		2 containers.
Miami [1]	1,871	771,798	345,797 bunches, 520 pounds, 1,526 units.	15	62	28 pounds, 366 units				6	13	92 pounds.
Mobile	216	4	3,174,504 bunches	9	15,313	1,000 pounds	3	201				
Naco	1	5								1	20	
New Orleans	1,476	256,628	11,492,296 bunches	6	5,277	8 pounds	42	5,794		1	1,980	
New Orleans, for export	22	5,036	50 units	1	1		2	200				
New York	10,255	3,908,443	10,888,345 bunches, 17,890 units, 24 pounds.	1,972	101,471	27,565 pounds	1,150	193,672	47,587 containers	69	73,225	1,204 containers.
New York, for export	575	216,839		143	1,978	20,027 pounds	365	50,315	3,428 containers	37	1,548	7,052 containers.
Niagara Falls [2]	156	2,553		244	125	19,412 units, 619 pounds	131	2,325		1	1,010	

[1] Collaborators stationed at these ports.

[2] Work handled by inspector at Buffalo.

TABLE 13.—*Summary of importations of plants and plant products inspected, fiscal year 1940*—Continued

Port	Fruits and vegetables			Nursery stock and seeds			Bagging, cotton, cotton products			Bagasse, broomcorn, corn, rice, fiber, etc.		
	Lots	Containers	Additional quantities	Lots	Containers	Additional quantities	Lots	Bales	Additional quantities	Lots	Bushels	
		Number			*Number*			*Number*			*Number*	
Niagara Falls, for export							8	136				
Nogales	2,476	1,118,015	2,609 pounds, 5,368 units	14		682 units				7		306 dozen.
Nogales, for export	33	2,371		3	3	22 pounds						
Norfolk	43	110	360,667 bunches	42	2,391		87	9,682				
Pensacola [1]	1		1,569 bunches									
Philadelphia	161	9,504	3,904,143 bunches	72	3,888	103 pounds	62	10,457	48,446 containers	6	6,819	
Port Huron [3]				45	68	1,223 units	42	3,232				
Portland	27	92	201,880 bunches	6	138		8	314				50 pounds.
Presidio	2	2								2	1	
Providence [4]							20	4,450				
Puerto Rico	72	20,306	162 units, 14 bunches, 50 pounds.	173	6,424	5,588 units, 2,710 pounds				154	439,775	
Puerto Rico, for export	3	31								(5)	635	
Roma	1	86										
St. Albans	7	630		2	4		73	3,329	9 containers	302	1,476,185	
St. Albans, for export							2	400				
St. Paul							14	186				
San Diego [1]	14	26	10,587 bunches	3		1 pound						8 containers.
San Francisco [1]	1,129	13,320	1,221,574 bunches	260	3,281	7,540 pounds, 257 units	67	3,542	10 containers	3		
San Francisco, for export	8	9		10	20	26,625 pounds	8	1,837	1 container			
San Luis [6]										1	60	2 containers.
San Pedro [1]	536	10,289	2,178,409 bunches	130	2,524	10,600 pounds	67	9,098		2		
San Pedro, for export	1	1		1	1		1		1 container			
San Ysidro	62	293	105,302 pounds	15	6	666 units						
San Ysidro, for export	10	4,179	30,975 pounds									
Sault Ste. Marie [3]	20		3,418 bunches									
Savannah				6	2,752		2	60				
Seattle	247	220,042	701,457 bunches	347	58,793	2,830 units, 12,569 pounds.	30	1,139		1	36	
Seattle, for export	5	13		3	5	15 units						
Tampa [1]	1,080	73,470	653,875 bunches	2		10 pounds, 150 units						
Vermont customs district. [7]				2	1	12 units	3	48				
Washington, D. C	3	3		2,575	4,636	318 units, 6,386 pounds	5		5 containers	1	2	
Total	30,856			7,014			3,871			733		
Total all lots, 42,474												

[3] Handled through customs.
[4] Work handled by inspector at Boston.
[5] Out of 4 lots.
[6] Work handled by inspector at Calexico.
[7] Work handled by inspector at St. Albans.

In addition to the commodities listed in table 13, 507 lots of plant material were entered at Canadian border ports where no plant-quarantine inspectors are stationed, through the cooperation of the customs officers and of the Division of Foreign Pests Suppression of the Canadian Department of Agriculture. These importations consisted of 22 lots, containing 90 lugs of tomatoes and 3,418 bunches of bananas; 170 lots, consisting of 5,485 bales of bagging, cotton, and cotton waste; 162 lots, totaling 381,499 bushels of shelled corn; 3 lots, consisting of 48 broomcorn brooms; and 150 lots of nursery stock, consisting of 691 containers and 1,670 individual plants.

At the Mexican border ports there were several thousand importations of fruits and vegetables in such small quantities that no entries were required by customs and no plant-quarantine record of them was kept, hence they do not appear in the table. All these small importations were carefully inspected before being released, and their handling represented a great deal of work, especially at the larger ports.

Many of the ports have devoted considerable time to the inspection of packing materials used in connection with commodities not subject to plant-quarantine restriction. When prohibited packing material is discovered, it must be treated or removed and destroyed under the supervision of a plant-quarantine inspector. Shipments of imported liquors have continued to arrive packed with straw jackets which have been contaminated with vetch plants bearing seeds infested with living bruchids. All jackets in which living bruchids were found had to be removed and destroyed or given to fumigation approved for imported vetch seed found to be infested with living bruchids.

DISINFECTION

Disinfection is required of certain commodities as a condition of entry and of other commodities when inspection reveals the presence of injurious insects or plant diseases. The following plant material was treated under the supervision of inspectors and collaborators of this Bureau:

Bagasse	66 bales.
Bagging	2,720 bales.
Broomcorn	967 packages.
Chestnuts	10,634 cases.
Cipollini	23,920 cases.
Cotton	162,232 bales.
Cotton linters	64,103 bales.
Cotton samples	10,012 packages.
Cotton waste	24,128 bales.
Grapes	2,432 containers.
Kudzu seed	63 bags.
Lima beans	14,888 containers.
Miscellaneous plants	837 containers, 45,424 units.[1]
Narcissus	13 containers, 2,763 units.[1]
Peaches	606 containers.
Pigeonpeas	5,578 containers.
Rags	30 bales.
Rice fiber	196 bales.
String beans	1,471 hampers.
Tree seed	154 packages, 3,176 pounds.
Vetch seed	492 bags.

[1] Refers to plants, cuttings, bulbs, roots, or other propagating units concerned.

AIRPLANE INSPECTION

The number of airplanes from foreign countries has continued to increase, and the possibility of introducing plant pests through this rapid means of transportation has increased accordingly. During the year 5,279 airplanes from foreign countries were inspected. These inspections were made at the following 21 ports of entry: Douglas and Nogales, Ariz.; Calexico, Los Angeles, San Diego, and San Francisco, Calif.; Key West, Miami, Pensacola, and West Palm Beach, Fla.; Honolulu, T. H.; Baltimore, Md.; Boston, Mass.; New York, N. Y.; San Juan, P. R.; Charleston, S. C.; Brownville, El Paso, and Laredo, Tex.; Norfolk, Va.; and Seattle, Wash.

Seven hundred and twenty-eight of the airplanes inspected were found to carry prohibited plant material, much of which came from places where it is known to be the host of injurious plant pests. One thousand two hundred and fifty-nine interceptions of insects and plant diseases were made in connection with the airplane inspection. These represented specimens taken from plant material carried in baggage, cargo, and stores, and also insects which were being carried as stowaways on the planes. These interceptions are not only of interest as possible plant pests, but many of them represented different species of mosquitoes and other insects that might have decided importance from the human-health standpoint.

While most of the interceptions represented forms which may be considered as having little economic importance, there were many interceptions which could be identified as to genus only, hence it is impossible to estimate their importance from a plant-pest standpoint. Interceptions of such well-known pests as fruitflies belonging to the genus *Anastrepha*, species of Aleyrodidae, the pink bollworm, and several species of coccids were included.

FOREIGN PARCEL-POST INSPECTION

Inspection of foreign parcel-post packages is carried on through the cooperation of customs and post-office officials. Under an arrangement which has been in effect many years, foreign mail packages found to contain plants or plant products are referred to inspectors of this Bureau for examination. Such packages arriving at ports of entry where no plant-quarantine inspectors are stationed are forwarded to the nearest port where inspection can be made.

A record by port of the number and disposition of foreign parcel-post packages inspected appears in table 14.

TABLE 14.—*Foreign parcel-post packages inspected, fiscal year 1940*

Port	Inspected	Refused entry (entire or in part)	Diverted to Washington	Released under permit
Atlanta [1]	63	0	2	1
Baltimore	1,004	13	96	36
Boston	4,243	61	690	38
Brownsville [2]	936	0	1	0
Buffalo	1,382	24	60	14
Chicago	10,833	62	114	290
Detroit	3,087	46	59	318
Eagle Pass	733	0	2	0
El Paso	531	8	11	13
Galveston	5	0	0	0
Honolulu [1]	2,744	300	1	197
Houston [3]	347	3	82	0
Jacksonville [1]	141	3	11	13
Laredo	3,136	7	6	12
Los Angeles [1] [4]	3,858	46	4	26
Miami [1]	66	12	10	11
New Orleans [5]	228	8	66	13
New York	263,137	212	3,272	191
Nogales [6]	532	3	1	1
Philadelphia	22,144	34	215	51
Portland	724	7	6	23
Puerto Rico (all ports)	47	2	1	39
St. Albans	704	2	87	8
St. Paul	23,543	38	50	63
San Diego [1]	45	2	0	0
San Francisco [1]	6,006	55	0	490
Seattle	1,552	26	1	368
Tampa [1]	6	0	1	1
Washington	11,106	73	0	741
Total	362,883	1,047	4,849	2,958

[1] Collaborators are stationed at these ports.
[2] 1 package was diverted to San Francisco for disposition.
[3] 82 packages (cotton samples) were diverted to Brownsville for fumigation.
[4] 95 packages were diverted to San Francisco for disposition.
[5] 4 packages were diverted to San Francisco and 1 to Honolulu for disposition.
[6] 5 packages were diverted to San Francisco for disposition.

MEXICAN-BORDER SERVICE

A total of 36,475 freight cars from Mexico were inspected during the year, which represents an increase of 963 over the number inspected during 1939. One hundred and seven more freight cars were fumigated in 1940 than in 1939. All cars found contaminated with cottonseed were required to be cleaned before entry was permitted. The usual fee of $4 was charged for each car fumigated, and all fees collected were covered into the Treasury as miscellaneous receipts.

A summary of the railway-car inspection and fumigation is shown in table 15.

TABLE 15.—*Inspection and fumigation of railway cars crossing the border from Mexico, fiscal year 1940*

Port	Cars inspected	Cars with cottonseed	Cars entered	Cars fumigated	Fees collected
	Number	*Number*	*Number*	*Number*	*Dollars*
Brownsville	1,843	142	1,842	156	624
Douglas	2,173	18	2,173	20	80
Eagle Pass	1,773	265	1,773	525	2,200
El Paso	10,850	425	9,768	[1] 679	2,920
Laredo	12,342	704	12,342	2,088	8,064
Naco	1,116	16	1,115	13	52
Nogales	5,860	298	5,627	634	2,600
Presidio	518	20	516	16	68
Total	36,475	1,888	35,156	4,131	[2] 16,608

[1] Includes 5 cars not from Mexico.
[2] The apparent discrepancy in fees collected and the number of cars fumigated may be explained by the fact that it is customary for the railroads to purchase fumigation coupons in advance.

In addition to the freight cars listed in table 15, 4,318 pullman and passenger coaches entered and were inspected at the following ports: Douglas, 7; El Paso, 1,317; Laredo, 2,557; and Nogales, 437.

Owing to the continuing improvement of highways in Mexico, there was an increase in the automobile traffic between the two countries. In cooperation with the Customs Service, 4,965,260 vehicles and 562,113 pieces of personal baggage were examined.

INSPECTION IN PUERTO RICO AND HAWAII

The enforcement of Quarantine No. 58, governing the movement of fresh fruits and vegetables from Puerto Rico to the mainland, is taken care of by plant-quarantine inspectors and insular inspectors serving as collaborators. Inspections are made in the orchards and fields, in packing houses, and on the docks, of such fruits and vegetables as are permitted to move to the mainland. During the year 2,670 shipments, consisting of 290 bunches of bananas, 443,037 crates of pineapples, and 16,032,915 pounds of other approved fruits and vegetables were certified for such movement.

With the cooperation of post-office officials, parcel-post packages destined for points on the mainland were inspected at the four main post offices on the island. This arrangement makes it possible to intercept much prohibited plant material before it leaves the island and also reduces considerably the number of Puerto Rican mail packages requiring inspection on arrival in New York.

A total of 3,050 parcel-post packages were examined, and 103 were found to contain prohibited plant material and were returned to the sender.

The enforcement of foreign plant quarantines and regulations as they affect the entry of foreign plants and plant products into the island is under the general supervision of the inspector in charge of the enforcement of the provisions of Quarantine No. 58, who is also assisted in this phase of the work by the collaborators referred to above.

In Hawaii the enforcement of foreign plant quarantines is handled wholly by insular inspectors serving as collaborators. The inspectors of this Bureau stationed in the Hawaiian Islands are engaged in the enforcement of Quarantine No. 13, which governs the movement of fresh fruits and vegetables to the mainland.

During the year 3,200 shipments, consisting of 116,649 bunches of bananas, 104,247 crates of pineapples, 70,047 coconuts, and 3,252,071 pounds of other approved fruits and vegetables, were inspected and certified for movement to the mainland. Of these, 565 pounds of avocados, 5,929 pounds of cucumbers, 206,589 pounds of papayas, 468 pounds of peppers, 76 pounds of squash, and 680 pounds of tomatoes were given approved sterilization treatments in Hawaii under close supervision.

Inspections were made in the fields, in packing houses, and on the docks. The inspection of parcel-post packages destined for points on the mainland requires considerable time and effort. During the year 397,935 such packages were handled; 117,851 of these were opened and inspected, and 112 were found to contain prohibited plant material.

Since the inauguration of trans-Pacific air service it has been the practice not only to inspect the planes when they arrive from the Orient but also to inspect all planes, baggage, and express before the planes leave Honolulu for California. This procedure serves as an added precaution against the carrying of plant pests from Hawaii to the mainland and permits the prompt release of baggage and express upon arrival at the mainland. Under this arrangement 58 airplanes, 2,248 pieces of baggage, and 2,995 air-express packages were inspected. The airplanes arriving in Hawaii from foreign countries are included under the heading Airplane Inspection.

Other activities in Hawaii consisted in the inspection and sealing of 3,478 pieces of baggage and the inspection of 514 pieces of express leaving Hawaii by boat.

INSPECTION OF SPECIAL-PERMIT AND DEPARTMENTAL PLANT MATERIAL

Importations of propagating plant material are inspected at special ports of entry designated for that purpose. Most of such importations are inspected and treated at the inspection house in Washington, D. C., which has the same status as other ports of entry listed in tables 13, 14, 17, 18, and 19.

Recognition, however, should be given to the fact that the greater part of the importations handled in Washington, D. C., represented special-permit material and, as such, received very close inspection and frequently some sort of treatment as a condition of entry.

The enforcement of the regulations governing the movement of plant material into and out of the District of Columbia required the inspection of 821 shipments of incoming domestic material (consisting of 127,601 plants, cuttings, bulbs, etc., and 1,598 lots of seeds), 275 of which received some form of treatment for the elimination of pests; and 2,312 shipments of outgoing domestic material (consisting of 165,357 plants, cuttings, bulbs, etc., and 14,500 lots of seeds). In addition, 14,343 containers of domestic plant material were inspected at the post office and at railway and express stations.

Twenty-one carloads of Christmas trees, 3 carloads of plants, and 276,044 plants arriving by truck were inspected.

INSPECTION OF PLANT-INTRODUCTION AND PROPAGATING GARDENS

Plant material which is being propagated at plant-introduction gardens maintained by the Bureau of Plant Industry and the Soil Conservation Service is inspected at regular intervals for the presence of plant pests. Plant material distributed from the plant-introduction gardens at Coconut Grove, Fla., and Mandan, N. Dak., was inspected by State officials cooperating with this Bureau. The inspections at the plant-introduction garden at Chico, Calif., were handled jointly by an inspector of this Bureau and an entomologist from the California State Department of Agriculture. Material distributed from the District of Columbia, Maryland, and Savannah, Ga., was examined by inspectors of the Bureau. A summary of these inspections appears in table 16.

TABLE 16.—*Plants, bud sticks, cuttings, tubers, roots, and shipments of seeds examined for distribution from plant-introduction and propagating gardens, fiscal year 1940*

Garden	Plants	Shipments of seeds	Bud sticks and cuttings	Roots and tubers
Bell, Md.	57,508	107	1,280	21,618
Chico, Calif.	3,896	136	1,595	0
Coconut Grove, Fla.	10,933	63	1,051	75
Savannah, Ga.	5,552	5	352	785
Mandan, N. Dak.	188,084	----------	----------	----------
Beltsville, Md.[1]	308,000	----------	----------	----------
District of Columbia	6,621	8,235	4,761	8,860
Total	580,594	8,546	9,039	31,338

[1] These plants were grown and shipped by the Soil Conservation Service.

INTERCEPTIONS OF PROHIBITED AND RESTRICTED PLANTS AND PLANT PRODUCTS

The inspection of ships, airplanes, vehicles, cargo, baggage, ship's stores and quarters, and foreign mail packages at the various maritime and border ports of entry resulted in the interception of large quantities of prohibited and restricted plant material. Much of this material was infested with insects or infected with plant diseases of considerable economic importance. In classifying the interceptions, those made at bridges and crossings at the Mexican and Canadian border ports have been considered as having been taken from baggage. A record of the number of interceptions of prohibited and restricted plant material appears in table 17.

TABLE 17.—*Number of interceptions of prohibited and restricted plants and plant products, fiscal year 1940*

Port	In baggage		In cargo		In mail		In quarters		In stores		Total	
	Prohibited	Restricted	Prohibited	Restricted	Prohibited	Restricted	Prohibited	Restricted	Prohibited	Restricted	Prohibited	Restricted
Baltimore	14	7	47	1	17	2	67	0	212	1	357	11
Blaine	926	675									926	675
Boston	57	34	2	8	25	38	43	17	469	105	596	202
Brownsville	6,000	781									6,000	781
Brunswick [1]	2	0					7	0	2	0	11	0
Buffalo [2]	4	348	3	0	21	2	0	1	0	1	28	352
Calexico	3,624	105									3,624	105
Charleston	1	3					45	0	14	1	60	4
Chicago	0	0	10	4	54	7					64	11
Del Rio	672	166									672	166
Detroit	17	572	5	2	35	19					57	593
Douglas	502	74									502	74
Eagle Pass	1,434	256									1,434	256
El Paso	5,639	844	137	78	18	5					5,794	927
Galveston	3	0					325	0	110	0	438	0
Gulfport [3]	0	0					14	1	4	0	18	1
Hidalgo	2,985	431									2,985	431
Honolulu [4]	437	149	78	9	282	2			15	3	812	163
Houston					2	0	254	0	31	0	287	0
Jacksonville [4]	5	1	3	1	2	0	11	2	40	4	61	8
Key West [4]	78	68					0	4	7	0	85	72
Laredo	16,362	1,249			14	7					16,376	1,256
Los Angeles [4]	10	7	0	1	43	2					53	10
Mercedes	173	41									173	41
Miami [4]	1,230	1,323	15	9	11	2	186	525	77	10	1,519	1,869
Mobile	11	3					311	7	76	5	398	15
Naco	104	37									104	37
New Orleans	187	64	11	1	8	1	859	62	203	6	1,268	134
Newport News							46	0	9	0	55	0
New York	2,000	462	270	27	150	112	145	22	135	40	2,700	663
Nogales	3,031	737			4	4					3,035	741
Norfolk	1	1					312	3	47	3	360	7
Pensacola [4]	2	0					27	0	8	0	37	0
Philadelphia	11	3	13	1	29	6	69	11	62	4	184	25
Port Arthur	9	0					547	2	117	0	673	2
Port Huron [5]	7	443									7	443
Portland, Oreg	1	0	1	0	4	1	1	0	51	0	58	1
Port San Luis [4]							1	0			1	0

[1] Work handled by inspector stationed at Savannah.
[2] Includes interceptions made at Niagara Falls.
[3] Work handled by inspectors stationed at Mobile.
[4] Collaborators stationed at these ports.
[5] Work handled through customs.

TABLE 17.—*Number of interceptions of prohibited and restricted plants and plant products, fiscal year 1940*—Continued

Port	In baggage		In cargo		In mail		In quarters		In stores		Total	
	Prohibited	Restricted	Prohibited	Restricted	Prohibited	Restricted	Prohibited	Restricted	Prohibited	Restricted	Prohibited	Restricted
Presidio	145	29									145	29
Puerto Rico (all ports)	53	52					3	1	3	1	59	54
Roma	120	12									120	12
St. Albans	0	5	1	1	0	4					1	10
St. Paul					14	24					14	24
San Diego [4]	10	6			1	0	35	10	55	4	101	20
San Francisco [4]	190	5	29	3	42	12	100	0	127	0	488	20
San Pedro [4]	437	16	26	7			63	0	180	2	706	25
San Ysidro	9,690	855									9,690	855
Sault Ste. Marie [5]	1	34									1	34
Savannah							160	0	23	0	183	0
Seattle	318	28	16	3	16	7	57	2	34	0	441	40
Tampa [4]	23	23	1	0			8	2	13	0	45	25
West Palm Beach [4]	6	1					2	0	1	0	9	1
Wilmington [6]							4	0	4	0	8	0
Total	56,532	9,950	668	156	792	257	3,702	672	2,129	190	63,823	11,225

[4] Collaborators stationed at these ports.
[5] Work handled through customers.
[6] Work handled by inspector stationed at Charleston.

PESTS INTERCEPTED

The inspectors and collaborators of the Bureau collected from foreign plants and plant products insects belonging to 1,186 recognized species and others distributed among 906 genera and families, fungi and bacteria belonging to 325 recognized species, and numbers of interceptions of diseases caused by fungi, bacteria, viruses, or other types of pathogens that could be referred to family, genus, or other group only. Many of these interceptions were of economic importance or of scientific interest, or both, including a number of apparently undescribed species.

A total of 70,622 interceptions of insects and plant diseases were made during the year. A summary of the interceptions appears in table 18.

TABLE 18.—*Number of interceptions of insects and plant diseases made during the fiscal year 1940*

Port	Cargo		Stores		Baggage		Quarters		Mail		Total	
	Insects	Diseases	Insects	Diseases	Insects	Diseases	Insects	Diseases	Insects	Diseases	Insects	Diseases
Baltimore	48	7	48	23	4	0	0	0	7	0	107	30
Blaine	14	6	0	0	47	15	0	0	0	0	61	21
Boston	136	98	128	61	20	4	23	15	87	15	394	193
Brownsville	775	77	12	2	6,659	3,100	0	0	1	1	7,447	3,180
Buffalo	41	54	0	1	0	2	5	0	15	13	61	70
Calexico	1	1	0	0	499	81	0	0	0	0	500	82
Charleston	115	1	4	0	0	0	0	0	0	0	119	1
Chicago	33	0	0	0	1	0	0	0	28	1	62	1
Del Rio	0	0	0	0	305	1	0	0	0	0	305	1
Detroit	2	20	2	5	2	0	0	0	26	11	32	36
Douglas	0	2	0	0	485	6	0	0	0	0	485	8
Eagle Pass	193	2	0	0	741	36	0	0	0	0	934	38
El Paso	1,048	228	0	0	3,714	789	6	0	9	2	4,777	1,019
Galveston	244	12	45	207	2	0	23	8	0	0	314	227
Guam [1]	0	0	0	0	0	0	108	0	0	0	108	0
Hidalgo	88	16	0	0	506	500	0	0	0	0	594	516
Honolulu [2]	131	0	2	0	51	0	321	0	159	0	664	0
Houston	0	0	102	102	0	0	7	0	2	0	111	102
Jacksonville [2]	8	4	44	34	4	0	9	2	0	0	65	40
Key West [2]	0	0	4	3	12	2	0	0	0	0	16	5
Laredo	1,479	67	0	0	3,702	135	0	0	23	1	5,204	203
Los Angeles [2]	1	0	0	0	2	0	0	0	2	0	5	0
Mercedes	0	0	0	0	101	40	0	0	0	0	101	40
Miami [2] [3]	101	26	13	9	282	28	220	3	2	0	618	66
Mobile [4]	18	0	44	31	2	0	15	2	0	0	79	33
Naco	1	0	0	70	78	12	0	0	0	0	79	12
New Orleans	380	14	100	25	27	4	22	3	7	1	536	47
Newport News	1	0	13	0	0	0	0	0	0	0	14	0
New York	2,290	5,578	410	435	495	267	51	22	158	14	3,404	6,316
Nogales	4,244	3,131	0	0	6,004	1,361	0	0	5	0	10,253	4,492
Norfolk	48	0	25	2	1	0	0	0	0	0	74	2
Pensacola [2]	0	0	0	0	0	0	2	0	0	0	2	0
Philadelphia	90	220	108	1,240	0	11	13	44	38	33	249	1,548
Port Arthur	2	0	24	23	0	0	0	0	0	0	26	23
Portland, Oreg	24	2	34	19	0	0	0	0	9	0	67	21
Presidio	7	0	2	0	62	6	0	0	0	0	71	6
Roma	0	0	0	0	9	4	0	0	0	0	9	4
St. Albans	1	0	0	0	4	0	0	0	2	0	7	0
St. Paul	0	1	0	0	0	0	3	0	13	9	16	10
San Diego [2]	1	0	24	2	5	0	3	0	0	0	33	2
San Francisco [2]	1,820	257	141	7	955	9	36	0	454	142	3,406	415
San Juan, P. R	28	0	0	0	29	1	0	0	14	1	71	2
San Pedro [2]	644	8	351	110	259	9	8	3	0	0	1,262	130
San Ysidro	30	13	0	0	356	4	0	0	0	0	386	17
Savannah	9	4	57	18	0	0	0	1	0	0	66	23
Seattle	361	375	87	104	42	21	23	10	102	84	615	594
Tampa [2]	5	7	10	3	11	8	4	0	0	0	30	18
Washington, D. C	1,614	4,262	0	0	189	37	0	0	696	391	2,499	4,690
Total	16,076	14,493	1,834	2,466	25,667	6,493	902	113	1,859	719	46,338	24,284

[1] Closed August 4, 1939.
[2] Collaborators stationed at these ports.
[3] Includes 149 airplane interceptions made by Public Health Service.
[4] Includes interceptions made at Gulfport, Miss.

NOTE.—Inspectors stationed at Puerto Rico made 5 interceptions of insects during their field and packing-house inspection of fruits and vegetables for shipment to the mainland.

CERTIFICATION FOR EXPORT

During the year 5,680 certificates covering 1,419,387 containers of plants and plant products were issued to meet the sanitary requirements of foreign countries.

Export certificates were issued at 32 ports covering 69 different commodities which were exported to 80 foreign countries. Some of the more important commodities certified were the following: Apples, 553 shipments consisting of 267,782 boxes, 22,870 barrels, 640 baskets, and 28 straps; pears, 266 shipments consisting of 185,361 boxes and 1,300 half-boxes; potatoes, 1,326 shipments consisting of 435,074 bags, 74,590 crates, 5,796 barrels, 23 boxes, 216 baskets, and 26 packages.

Many of the shipments of apples and pears were certified under the cooperative arrangement with the Bureau of Agricultural Economics of the Department, whereby licensed inspectors of that Bureau located at shipping points make inspections and issue reports which are accepted by the plant-quarantine inspectors at the ports of export as a basis for issuing the required export certificates.

A brief summary of the export-certification work appears in table 19.

TABLE 19.—*Certification for export, by port, fiscal year 1940*

Port	Certificates issued	Total containers certified	Commodities certified	Foreign countries	Port	Certificates issued	Total containers certified	Commodities certified	Foreign countries
	Number	*Number*	*Number*	*Number*		*Number*	*Number*	*Number*	*Number*
Baltimore	19	73	5	4	Newport News	93	5,853	1	7
Boston	33	20,550	3	6	New York	3,870	808,870	41	54
Brownsville	11	6,132	3	1	Nogales	24	1,306	3	1
Buffalo	3	48	3	2	Norfolk	17	582	1	2
Calexico	42	29,234	4	1	Pensacola	4	225	1	1
Canal Zone	4	6	1	3	Philadelphia	4	7	1	3
Chicago	5	553	2	2	Portland	223	89,605	13	12
Detroit	182	6,951	5	4	San Diego	1	9	1	1
El Paso	49	486	10	1	San Francisco	250	94,765	19	11
Hidalgo	16	377	5	1	San Juan	2	2	2	2
Houston	3	4	1	3	San Pedro	190	83,057	8	4
Laredo	11	2,823	3	1	Savannah	1	54	1	1
Los Angeles	112	11,116	11	4	Seattle	155	241,619	15	9
Mayaguez	1	1	1	1	Tampa	10	282	3	2
Miami	4	810	3	3	Washington	290	339	8	57
Mobile	5	2,101	3	2					
New Orleans	46	11,547	9	7	Total	5,680	1,419,387	----	----

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